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Admiral Sir HENRY J. CODRINGTON, K.C.B., Chairman of the Council, in the Chair.

COTTON-POWDER FOR MILITARY AND NAVAL PURPOSES.

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The works of which I have charge at Faversham are now fully occupied in making powder for commercial purposes: they are indeed, although the site is an extensive one—only the first instalment of factory-works put up to assure the foundation of a manufacture, which, as these works are extended, will increase into a national industry. Consequently, although from time to time various trials have been made and various experiments carried out, in view of military and naval applications of cotton-powder, yet experiments in this direction have not been pushed forward actively, and the present state of results is imperfect in a large degree, although enough has been accomplished and still more indicated, to make the subject one of interest to this audience.

We have now had three years' experience of cotton-powder in the very considerable quantities which have been used for mining, tunnelling, and quarrying, as well as for submarine operations in the clearance of wrecks. We know, too, from numerous operations on trees, timber, boulders, masonry, and iron, steel, slag, and cinder, its capacities for demolition: and we have at least one example of its success in practical military work in the recent experiments at Eastbourne.

The cotton-powder, therefore, is an actual fact: it is *not* a theoretical idea: nor an untried novelty. It was not born like gun-cotton and nitro-glycerine in the early days of the age of explosives, when the untilled fields of the whole world were open: but it has had to fight for existence from the day it went into the market against most powerful established rivals famous everywhere—gun-cotton and dynamite: and against this latter, its strongest competitor, in all places where it has been introduced it has been firmly winning a superior position. Its quality of power, therefore, has had tangible

demonstration. Again, in the various samples which have been sent abroad to different parts of the world, undergoing temperatures of every variety, there is actual proof of its stability under climatic changes: and, finally, up to the present time we have not had a single accident attributable to cotton-powder: and only five in any way, directly and indirectly, connected with its employment.

This short summary of its commercial career is sufficient to show that cotton-powder is a marked, special, and extraordinary explosive.

Cotton-powder consists of the purest gun-cotton crushed to an impalpable dust, and purified from all bastard products due to the combinations of nitric acid with the starches, gums, oils, resins, and other impurities of the cotton: and intimately mixed with an oxidizing substance, by incorporation like ordinary gunpowder, in such proportions as to produce the highest possible effects in the explosion.[1]

The qualifications properly looked for in an explosive are 1, Safety: 2, Power: 3, Handiness in Use: 4, Cheapness.

I. On the first head "Safety": it is that the most important progress has been made in cotton-powder. Twenty years ago gun-cotton took a month to wash; and even with double that period of mere immersion in running water was never thoroughly freed from the acids and injurious nitrous impurities. Vast as was the improvement made by Mr. Abel in pulping the gun-cotton, and so by dividing the fibre into very minute lengths to facilitate the washing process—which it reduced from six weeks to two or three days—yet the mere mechanical ablution in the poacher never entirely frees the gun-cotton from the bye-products of resins, starches, oils, and so forth, with the nitric acid: hence the various spontaneous decompositions and accidents which have from time to time occurred; for these products give way at far lower temperatures than the gun-cotton proper, or pure nitro-cellulose. In this one branch alone, if nothing else had been done, the process of purification would have given character to the Faversham Cotton-Powder Works; for, in two hours the gun-cotton made there is rendered absolutely pure and free from all deleterious substances. This is attained by air-washing and steam-boiling. About a ton of pulverized gun-cotton is put in a large volume of water in a vat of inverted pyramidal shape, and a current of air is injected which agitates thoroughly the fluid. The boiling by means of steam similarly injected eliminates by actual chemical decomposition into gaseous conditions those nitrous compounds which have been hitherto the source of so much mischief in ordinary gun-cotton: and more important still by the use of carbonate of ammonia, the "red fumes," or nitrous oxide, are in this way thoroughly destroyed.

The purity of the gun-cotton in the cotton-powder is the basis of its safety. It is this quality of purity which puts cotton-powder to the front of all other explosives, and will give it sooner or later the command of the market.

This quality above all others is needful in any explosive employed for military and naval purposes, particularly the latter, for on ship-

[1] Samples of the raw and manufactured materials were here shown to the audience.

board it is the one condition of safety, which is everything; indeed, where the very existence of officers and crew depends on the integrity of the vessel, none other than a thoroughly reliable explosive can be permitted at all. It is the absence of this perfect purity which renders it needful to store ordinary gun-cotton in a wet state, and makes it dangerous to store inferior gun-cotton in any state whatever. It is the absence of this perfect purity that gives to nitro-glycerine and its compounds some of their most serious defects.

To obtain this perfect purity nothing is left undone at the Faversham Works, for, although two hours suffice for the boiling, yet it is continued for from twelve to twenty-four hours, so great is the stress laid upon the value of perfection of manufacture.

In short, if one wanted to lay down an axiom, one would say no explosive is any good that will not stand boiling.

II. The next point in the manufacture of cotton-powder is the incorporation of the purified gun-cotton with an oxidizing substance—the source of its superior power.

In blasting in quarries, so in military demolitions, in submarine mines and torpedoes, in the bursting charges of projectiles from guns, the utmost amount of disruption is expected. In all these purposes, therefore, the full force of the "explosive" is required to be instantaneously exerted—the total possible destruction being attainable only through the absolute instaneity of evolution of the destroying force.

This instantaneous production of the full extent of power is commonly obtained by detonation, or the instantaneous chemical disruption locally effected by a fulminate, and which once initiated is carried equally instantaneously through the mass of the susceptible explosive.

The admixture of an absorbent earth with the explosive oil nitro-glycerine, for the convenience of use in practical operations adds nothing to its strength, but on the contrary, there is diminution of power proportionate to the extent of the adulteration. The admixture of gun-cotton with an oxidizing substance—preferably in cotton-powder, the nitrate of baryta—on the contrary most materially adds force to the primitive explosive.

If we look at any tabulated statement of the "heat" given out on explosion by various substances and compounds, we are struck with the poor appearance made by gun-cotton.

Nitro-glycerine, for example, disengages 1,320 units;[1] whilst Abel's gun-cotton yields only 590 units or actually less than common gunpowder, which stands at 600 units.

When we seek for the reason, we find that the glycerine has combined chemically with a larger proportion of gas or nitric oxide from the bath than the cotton, and consequently there are better chemical relations in the nitro-glycerine than in the gun-cotton.

III. It is, therefore, by satisfying more fully the carbon base of the gun-cotton, that we have to look for an increase of power. And this

[1] The unit is the quantity of heat required to raise one kilogramme of water one degree centigrade, and the figures given correspond to one kilogramme of the explosive burnt or exploded.—S. J. M.

we find to be the case. Thus it is, that by incorporating the oxidizing materials in the proper combining and most efficient proportions, that we attain the highest power in the compound, cotton-powder, as well as the most satisfactory results in the comparative absence of noxious emanations from the explosion.

The saturation of gun-cotton by saltpetre was unsatisfactory, for the nitre being soluble, the influence of various degrees of moisture left the due explosion of the charge always doubtful; and on the other hand, the crystallization of the nitre caused the product when dry to crumble. Nitrate of baryta was thus a far preferable material because of its insolubility, and because of the less amount of energy requisite to evolve its gases in explosion. In fact, taking everything into consideration in the composition of cotton-powder, we have more force stored up and available than in any other explosive mixture.

If we take common gunpowder and satisfy the carbon in it with oxygen from chlorate of potash, we have the yield of heat at once increased to nearly double, or as 1,000 to 600 units; and a similar effect is produced with gun-cotton, the development of heat from chlorated gun-cotton reaching the highest point of 1,420 units, or 100 units in excess of nitro-glycerine itself.

IV. The chlorate of potash, from the readiness with which it gives up its oxygen, is commonly regarded as a dangerous substance; and it is well known that gunpowder, with chlorate of potash substituted for the nitre, is neither safe to make nor use. The first essays which were made to produce a blasting compound from the pulverized gun-cotton were with the chlorate of potash, but an accident—happily not of a fatal character—led to the substitution of the nitrate of baryta as the oxidizer; and from the very outset of this second compound, the cotton-powder, it has been a veritable success.

The incorporation of this oxidizer with the pulverulent gun-cotton gives to the compound a great deal of the nature and character of ordinary gunpowder—the carbon of the cotton taking the place of the charcoal, and the nitrate of baryta of the saltpetre—the sulphur being unnecessary because the gun-cotton itself is rapidly ignited. But the characteristic of gunpowder, namely, explosion by rapid combustion, is so far reduced by the high density of *cotton-powder*, that without the detonator it is simply a *combustible*. By mere ignition, it does not explode, but burns with an intense greenish flame. Nevertheless, like gun-cotton and nitro-glycerine, it is susceptible of detonation, only in a less ready degree, and therein further is its superiority of safety over those and all other known explosives.

The detonation being effected, the cotton-powder is equally remarkable for its superiority of *power*. Slight confinement or a slight load facilitates the detonation; or the rather more inertness of the cotton-powder can be got over equally well by an increase in the quantity of the initiating fulminate—the proportion practically adopted being as 3 to 1 in respect to dynamite, which can even be fired with caps containing $2\frac{1}{2}$ grains of the fulminate of mercury, whereas caps containing 15 grains are regularly sent out with the blasting charges of cotton-powder. This marked difference in the

strength of the caps is also an accurate measure of the relative safety of the two compounds in their everyday use and employment.

V. The stability of cotton-powder is also superior, not only to other explosives, but even to that of gunpowder itself. In gunpowder the sulphur may be a source of deterioration; and in the old books instances of spontaneous explosion are recorded, being probably of not infrequent occurrence when the art of gunpowder-making was not so skilful, nor the care of manipulation so great as in the present day.

It is well to bear in mind, too, that the materials of the cotton-powder are first tested for purity before manufacture, and the article itself again tested after manufacture, thus giving guarantees for its perfection. Whereas even now there is no guarantee for gunpowder —which is never tested at all.

VI. The form into which cotton-powder is made up for blasting and general use is undoubtedly the most convenient and the safest ever devised.

In the early stage of manufacture, the meal was dried and then after being weighed to the charge required, was poured through a funnel into a paper shell and rammed into it around a central paper tube, the whole being choked with a double-ended wire. The detonator being firmly nipped on to a Bickford or Brunton fuze, was inserted in the central tube, and the wire-tags being bound round the fuze in opposite directions, and their ends twisted, the fuze and cartridge were closely fixed together, and could not be pulled apart, or separated in the act of loading the charge, or afterwards by stemming over it, as is always liable when the capped fuze is merely put into a perforation, as in Abel's discs, without anything to hold it there.

When a detachment of this kind occurs in a mine, there is of course a miss-fire—always a source of danger—and there might be an unintended explosion by the ramming down of stones upon the cap, or by striking or forcing it crosswise on the charge. The primers of dynamite, soft putty-like substance that it is, are always more or less subject to similar accidents; whereas in the cotton-powder the cap is securely packed in the centre of the charge, and the tighter the stemming and the closer the ramming, the better the protection given to the detonator.

These first cartridges were made by hand, but now very powerful machinery is employed, and they are pressed up *wet* with a pressure of some five tons on the square inch, calculated to give a density of 1·6 to the powder when subsequently dried.

The improvement effected by this mechanical compression is very important; and as the cartridges are produced with far greater rapidity, they are consequently cheaper as well as better.

Finally, these cartridges are waterproofed in a composition of paraffin to enable them to be used in wet holes and under water. For great depths—as in the open sea—the tenacity of the waterproofing is increased to keep the charge dry, as against the increase of hydrostatic pressure.

VII. A few remarks may here be well made in respect to the quality of strength in the cotton-powder.

We have seen that chemically the power indicated for the strongest explosives is only about double that of ordinary gunpowder, whilst their evident effects are from at least three to five or six times that of gunpowder, and often even very much more. The quality of the power exerted is therefore clearly attributable to the nature of the explosion and of the explosive.

First, the higher the density of the explosive (or in other words the greater quantity within a given space) the greater the force therein located. Secondly, the closer in contact the particles of the explosive are, the more powerful and the quicker is the detonation; and thirdly, the more rapid the detonation the greater the force exerted by the explosive in consequence of the higher tension of the gases evolved. The density therefore of this explosive is another indication of its power, and in this respect cotton-powder shows off most favourably against its compeers. The density of gun-cotton is 1·0, or the like density as water; dynamite is given by Nobel as 1·50, while cotton-powder is pressed to 1·6, and can be produced with a density as high as 2·0.

Amongst the samples exhibited is a 1-lb. cube of cotton-powder compacted under such a pressure as to put the powder into a space of only about two-thirds of that occupied by the Service gun-cotton. One essential element in obtaining the superior compactness of cotton-powder is the fineness of its particles—compression being difficult and dangerous in proportion to the coarseness of the gun-cotton and the amount of fibre left in it. That rough kind of gun-cotton or tri-nitro-cellulose made from wood by Mr. Muschamp and called "*Patent Gun-*"*powder*," —a very different article from *Cotton Powder*—is notable in this respect, as the cartridges in which it is turned out for mining purposes are the least compressed of anything in the market; and possibly their fibrous condition would not allow of more compression without considerable risk.

VIII. The comparative freedom of an explosive from noxious gases and poisonous emanations is a very important matter for the consideration at least of those who pass their lives in the daily occupation of blasting in mines and tunnels. It is of less moment in military and naval work other than gunnery. For out-door operations a very large amount of fumes may be mingled with the atmosphere and so diluted as to be practically harmless. The fumes of dynamite and of lithofracteur may be smelt at distances of over half a mile from the explosion; and similarly gun-cotton gives off considerable volumes of carbonic oxide; and those who are acquainted with the use of the latter explosive for earth-mines and lodgments will have often seen a crackling-cloud of fiery gas blazing three or four feet above the recently disturbed and fissured soil, and will have heard successions of small reports amongst the clods which have fallen back into the crater. The extent of the emanations of nitrous-oxide from dynamite may often be well observed in subaqueous operations such as those of clearing away of submerged rocks in the bed of the Tees navigation, where the Diamond Rock Drill Company put down by the drill-barge as many as twenty-four or twenty-six holes at a time; and when these charges

are fired, the distinctions between the perfect detonations and the partial explosions are manifested most distinctly by the clear white foam rings of the former, and the huge bubbles of "red fumes," which come up from the latter—sometimes as many as half the shots belching forth the copper-coloured nitrous oxide in this manner.

The cotton-powder seems to be free from any dangerous noxious after-gases when properly detonated. When burnt, there is a pungent odour, but I have never experienced inconvenience from it even in close places; nevertheless the presence of any odour is a hint to be cautious, which it would be well always to pay a little attention to; but from charges effectually detonated, as all charges ought to be, with the strong caps supplied with the cotton-powder, there is absolutely nothing to prevent immediate entry after the blasts. There is a small amount of smoke after firing, consisting chiefly of heavy dust, for the nitrate of baryta—which is made from the carbonate, a natural earthy mineral called "Wetherite," by chemical treatment—is decomposed by the heat of the explosion, and re-formed by combination with the carbonic acid into carbonate of baryta. This dust-cloud quickly falls to the ground, especially if there be any moisture in the workings, leaving the atmosphere clear and wholesome. The other products of explosion are the vapour of water and some free nitrogen. Altogether the products of explosion of cotton-powder are then as little noxious as they well can be, and in this respect beyond any other explosive, and indeed far less injurious to health than the smoke of common gunpowder.

I have, myself, had very considerable experience of cotton-powder under all circumstances—often those of extreme closeness—and have never suffered in the least degree, although I have made it a practice to rush in instantly after firing.

In military mines this element of comparative freedom from smoke is of much consideration, as time is almost always of importance in such work; and the rapidity with which a military mine can be entered after the blast may in many instances be a vital gain to the operators.

IX. The final qualification of cotton-powder for military and naval purposes—as well as for general favour—appears to me to be its *cheapness*. This is the conclusive consideration in commercial transactions when two or more articles are of equal utility; and it is always a decisive ground for adoption when an article is superior to its competitors in most other respects.

The production of gun-cotton in the customary way is not a cheap manufacture. The cotton is far dearer than the charcoal of gunpowder, and indeed is a more expensive condition of carbon; each pound of cotton requires to be steeped in $10\frac{1}{2}$ lbs. of mixed nitric and sulphuric acids of the value of 1*s.* 9*d.*, of which three-quarters of a pound only is actually combined with the cotton—the produce being $1\frac{3}{4}$ lb., theoretically, of gun-cotton; but practically with the waste in the different operations it is really not much more than $1\frac{1}{2}$ lb. The remainder of the mixed acids not absorbed by the gun-cotton have always been regarded as "waste," and returned to the chemical

factory at a price of about a halfpenny per lb. If to this cost we add labour in manufacture, and wear and tear of machinery, and plant, buildings, packages, and so forth, and the total cost of the gun-cotton mounts up to 2*s*. per lb. If, however, we add 1 lb. of nitrate of baryta at 1*s*., we have 2 lbs. of powder for 3*s*., or cotton-powder at 1*s*. 6*d*. per lb.

Now, if I had strong commercial proclivities, I might be disposed to improve this occasion by showing that gun-cotton being sold *wet*, with 25 per cent. of moisture in it for "safety," is practically sold at 2*s*. 6*d*. per lb.; but then it would be retaliated that cotton-powder is sold at 2*s*. per lb., and therefore we have 25 per cent. of profit also. So we do; but we do not keep all that to ourselves when we get good customers. Nevertheless, without wishing to dwell on commercial topics, I would only add that it would be a great economy to the State, and a profitable engagement for our Company to convert the Government stores of excellent gun-cotton into still better cotton-powder; and I shall be very pleased indeed whenever the Chemist of the War Department and the Government authorities are of the same opinion.

X. Further progress in the direction of cheapness has been made by the introduction of charcoal into the cotton-powder; and a very good article (No. 3) has been produced in this manner. This brand has some very important qualities, and its safety and stability are singularly high. It will not indeed detonate alone, but requires a primer of the No. 2 cotton-powder (or of gun-cotton) to produce explosion. Its combustion is even more brilliant than that of No. 2, or the cotton-powder proper, and is peculiarly suitable for night signals, the light being visible for long distances, whilst the report from its explosion is very loud and sharp, and large cartridges can be heard for miles.

For open-air work it will in due time command an extensive application, and just as No. 2 brand is the rival of dynamite, so No. 3 brand will become the competitor with common gunpowder.

Shooting Powder.

XI. The first manufacture attempted at the Faversham Works was that of shooting-powder or cotton-gunpowder; and having introduced the subject of modifications of cotton-powder, it will be well not to pass over this notable one, which some day will in all likelihood again come forward. Any way, it is a topic not to be ignored in military and naval considerations.

A true gunpowder should not be susceptible of detonation, or, in other words of instantaneous chemical disruption; but the explosion of a gunpowder should be a combustion of very considerable rapidity, for the force required is a pushing force exerting itself upon the projectile as long as it remains in the barrel; and it should be a force increasing in direct ratio with the motion of the shot, if such be practicable. These effects we have seen of late years attained by variation in the dimensions of the "grains," or broken fragments of powder-cake—a form necessary for the free circulation of fire throughout the the charge. The intention in gunpowder is to furnish a propelling

force which shall not burst the gun, which is required to be preserved intact for the repetition of innumerable discharges. The practical purpose of gunpowder is thus diametrically opposite to that of blasting-powder.

To form a *gun*-powder from gun-cotton we have to substitute for the baryta another substance as the oxidizer, and to make further modifications in the composition and materials.

On the table are samples of very good small-arms and sporting powders made more than two years since, but the manufacture of which is for the time being suspended on account of the demand for blasting cartridges, which taxes the utmost resources of our present works. One fact of importance has been gained by our experience in this direction, namely, that very small quantities of fulminate must be used in the percussion-caps employed to fire the charges in guns; otherwise detonation will intervene to the destruction of the weapon; and doubtless this has been a cause of many of those accidents which have happened with gun-cotton, gun-sawdust, and similar nitro-cellulose products in the hands of sportsmen. The tendency to detonation was diminished in cotton-*gun*powder also by its excessively high density—pressures of from 30 to 50 tons being put upon the "cake"—which, like black gunpowder, was similarly broken up into "grains." The cotton-*gun*powder gives off very little smoke, which can be clearly seen through; whilst there is no fouling, but only a slight dusting of dry carbon on the interior of the barrel. The recoil, too, is easy, and the strain lighter than with ordinary sporting powder. There seems no reason why cubes of considerable sizes for cannon should not be in due time produced, whenever the subject is again taken up at the Faversham Works.

XII. Having given a tolerably full sketch of cotton-powder in its present stage as a commercial industry, it becomes my next duty to deal, as best I am able, with those topics which relate more particularly to its application to military and naval purposes.

Most of what might be primarily urged is of course what might be generally said in favour of the use of explosives for certain purposes in preference to gunpowder; but on this occasion I have no intention of being diffuse. We have not yet all the requisite accurate experiments, nor the means and apparatus requisite for a masterly discourse on the subject. Much of what we have done is crude, although the knowledge obtained is satisfactory. Again, over some of our details I am obliged to hold the veil of reticence until they are further advanced.

The first public experiments with cotton-powder were made at the Company's works in February, 1875, and of these some may be mentioned as demonstrating the superior properties of cotton-powder in a few of the more familiar requirements of military operations.

The first series of those experiments were illustrative of safety in transport, storage, and the loading with charges of cotton-powder. Some loose cartridges were burnt in the hand like torches, and two barrels—of the best possible make, and service gunpowder-barrel pattern, and materials without fissure, crack, or blemish, tightly coopered up, and containing 40 lbs. of powder each, one of No. 2 (white) and

one of No. 3 (black) cotton-powder—were placed over huge bonfires and roasted for six and seven minutes respectively when the powder took fire, and burnt in splendid globes of yellowish fire of intense brilliancy. Of course the executive were well up to the usual dodges in burning explosives; but we did not select boxes with screws easily drawn, and made of wood that would easily split; nor did we put the packages in the midst of the faggots, that the flames might lap over and light the powder on the top. But we wanted—for we had a good purpose—to show that we had an article which the railway authorities might safely permit to be carried over the lines committed to their care. So we built brick piers and put iron bars across, the barrels of cotton-powder being rested on them, and the faggots piled well on the windward side, that the barrels might have a good scorching before the powder in them ignited. So by manly, honest daring, we did succeed in our object, and the railways all over the United Kingdom and Ireland carry cotton-powder without fear or hesitation, and at no higher freights than ordinary gunpowder.

Since then we have had an accidental ignition of over 400 lbs. of cotton-powder, and no tendency to explosion was shown. Of course, I am well enough aware—for I was the first to inculcate the doctrine—that every explosive may be, to a greater or less extent, burnt harmlessly; but that it is a matter of certainty that the residual portion of a very large mass in conflagration will be sooner or later heated up to explosion point, and then explosion will follow. This point, however, is reached in very different periods, according to the nature of the explosive. In wet gun-cotton it takes some time and long-continued heating to effect this explosion, but in dynamite and nitro-glycerine compounds, the conduction of heat by the fluid oil quickly raises the temperature of the mass and explosion follows in a short time after ignition when the pile of explosive is close-packed and of any magnitude. It is thus easier to burn fifty 5-lb. boxes of dynamite than one 50-lb. barrel.

There is scarcely any conduction of heat in cotton-powder, and the cartridges burn very slowly, being at the rate of 1 to 5 inches of Abel's gun-cotton. The cartridges of No. 3 (black) burn still more slowly, and soon after ignition the fire can be easily cut out with a knife. We have had other and ample evidence that explosion will not follow on the conflagration of considerable quantities, and that even charges may be ignited by friction in bore-holes, and yet burn away harmlessly. It would, however, be most improper to encourage or permit trifling with "safety" in any explosive—all ought to be dealt with according to the most prudent rules, for a mistake cannot be retrieved, and a bad example may have improper imitations. It is different where one gets experience for the sake of others at the risk of one's self.

Another experiment was made at our works to show the non-liability of cotton-powder to explode under ordinary violent blows, namely, the fall from the height of 15 feet, of a half-ton pile-driver upon 10 lbs. of cotton-powder, in a box placed on a 12-inch pile driven into the marsh. Neither explosion, nor even ignition, followed on the blow.

But the most telling experiment, in the 1875 series, was the cutting

of four steel ingots, each over 4 feet long by 11 inches by 11 inches, in dimensions at the median portion (or 121 square inches of sectional area), by a charge of $2\frac{1}{2}$ lbs. of cotton-powder placed between them and packed with clay. These ingots, of the finest and toughest steel for submarine cable-wire, were cut as clean as by a hatchet, and the half pieces, weighing as much as 8 cwt., were hurled 40, 60, and even 90 yards away.

Illustrations of land mines and submarine mines were also given on that occasion, two being 30 lbs. charges; also a box, containing 20 lbs. wetted with 20 per cent. of moisture, and in an uninflammable condition was exploded unconfined, and so successfully that its report was the source of a considerable glazier's bill for the destruction of window-glass in our store shed.

A submarine mine of 50 lbs was fired and threw up a magnificent fountain in the waters of the Swale, the arm of sea which separates the Isle of Sheppey from the Kent shores of the cotton-powder works.

All these experiments have been confirmed by our subsequent experiences, and their testimony is undoubtedly valid.

XIII. The effects of cotton-powder in very *large blasts* was most satisfactorily tested in May, 1875, at South Shields, where gun-cotton, it is stated, had previously failed on two occasions, and where, subsequently, a trial of the "Patent Gunpowder" (Muschamp's) proved otherwise than remarkable, if the statements I have received be correct. Indeed, it seems difficult to make large blasts successful, in commercial operations, with limited charges, for the high prices of explosives restrict the quantities employed, and the only terms obtainable are those of "cost for cost," with common gunpowder, for so many thousands of tons of rock shifted; as was done in the case of the Trow Rock Quarry, referred to. The blast was an excellent one, the line of pegs indicating the area estimated to be disturbed by 3,000 lbs. of gunpowder being exceeded all round by about 10 to 15 feet, and a quantity of rock was shifted of over 25,000 tons. The work, too, was of good quality, for the purpose intended, the ground being riven and fissured in all directions, without being too much broken up.

Some blasts of smaller dimensions have been made in the great limestone quarries at Buxton, in which the cotton-powder was used with ordinary gunpowder, in the manner known provincially as "chirping," that is, the main charge was of common gunpowder, and this was fired by the cotton-powder charge put on the top of it, the work done being reported as very effective.

XIV. Reference has already been made to the usefulness of cotton-powder for signal purposes. Soon after the loss of the "Deutschland" I made some highly satisfactory trials in the Lledr Valley, in North Wales. The station selected was the high ground opposite the noble mountain, Moel Siabod. Men, with return-signal cartridges, were sent out to distances of one, two, four, and six miles, and, when the night was quite dark, 1-lb. charges of cotton-powder, of both brands, were alternately lighted and exploded, the light signals and the sound signals being returned, in all cases, by the observers up to the most distant. The light is quite as powerful as the lime-light, and the

report equal to that of a 40-pounder gun. The object of the experiments was to show that, whilst frequently in the case of wrecks at sea, roughness of the weather and the spray, by wetting the gunpowder, prevents the firing of the signal gun, the cotton-powder could be always used, either as a light or instead of a gun, as the cotton-powder would receive no injury from the water, and that, whilst the signal gun is limited in capacity of sound, the report from the cotton-powder could be increased to any requirement by the use of additional cartridges. All that would be required would be to run the cotton-powder charge up by a halyard a few feet clear of surrounding objects, with its Bickford fuze burning, and let it explode free in mid air.

The clearness with which surrounding objects were brought out of the darkness by the burning of a 1-lb. cube of the cotton-powder was remarkable, the whole immediate mountain side being illuminated for some fifty yards by fifty yards, and every object of any size being distinctly visible. Its qualities in this respect, as a most handy discovering light, will be thoroughly recognized whenever its applicability in this way is properly investigated. At night, ashore, for discovering attacking parties, and afloat, for the look-out for boats and torpedo vessels, and in other sudden emergencies, its readiness to hand and the non-requirement of apparatus—a bit of deal board or a spade making a sufficient expedient for a reflector—will be points of very practical service.

XV. Another application of cotton-powder for military purposes would be in the disabling or destruction of cannon. On a recent visit to South Wales, I was asked to break up some old and some badly cast tuyères, at the Ogmore Iron Works. These nozzles for the air-blasts of the furnaces are, as is well known, kept cool by currents of water circulating in a coil of wrought-iron pipes within the shell of cast-iron. This wrought iron pipe strengthens the construction immensely, and as these objects are of considerable size, 24 inches by 14 inches, and the walls 4 inches thick, they are not easily demolished by ordinary means, and it was thus, with a smile, that the manager brought them forward for operation. Having the broad ends turned down upon a pad of clay, laid on a thick bed of "old horse," or iron cinder, I had the tuyère filled with water, like a bucket, and putting into it a small cartridge, suspended by its fuze, the explosion took place in the water, and the nozzle was split easily into four nearly equal pieces, which were thrown apart only about four or five feet.

This principle might be applied to the breaking up of guns, and the medium of water effects great advantage over the using of explosives to act directly in breaking up metal, for fragments are then commonly thrown to great distances, involving dangers which no care of the operator can guard against. A single cartridge, with the water-tamping, would be ample for each operation, and if water could not be had in an emergency, plastic clay would make a passable substitute.

XVI. Another useful although simple application would be the cracking of blind shells, such as those falling into trenches or fortresses, which it would be objectionable to leave, and yet would be

more dangerous to unscrew or unload. A small charge of cotton-powder, applied externally and covered with a heavy pad of soft clay, will split the cast-iron shell without exploding its bursting charge. The minimum effective charge should not be exceeded in this operation.

XVII. In the various *submarine* operations which have been undertaken with cotton-powder for the removal of wrecks by various operators, reports have been received crediting it with very superior power for such duties. Indeed, for torpedoes and submarine mines, it possesses superior qualities. Over dynamite it has the advantage of never requiring thawing, and is free from the defects of deterioration by any exudation of its materials. Over compressed gun-cotton it has the advantage that much more in weight, and consequently much more of power can be got into the same space; thus, as much as 640 lbs. of cotton-meal-powder could be got into a Service torpedo intended for 500 lbs. of gun-cotton; and, compacted as it might be, more even than this might be got in.

For loading torpedoes and submarine mines, the *form* into which the cotton-powder is made up, is suitably varied. As a general rule, it is pressed into cubes of various sizes; but it has also been formed into grains for the purpose of loading through the loading-holes of torpedoes and mine-cases originally intended for gunpowder.

These cubes and grains are interpacked with *melted paraffin* run in between them in such a way that a waterproof walled chamber or cell is formed for each, and thus damage from the leakage or breaking of the mine or torpedo case will be limited to a portion, and will not extend to the whole of the charge. If the main mass of the charge remains in an effective state, it is capable of exploding the wetted portion. According to some experiments we have made, it would appear that it takes a weight of dry cotton-powder equal to the weight of water in a saturated charge to effect its proper explosion. The cubes of cotton-powder are usually 1 lb. and $\frac{1}{2}$ lb., but some as small as 1 oz. have been made.

II.—*Shells.*

XVIII. The cotton-powder *grains* are also useful for *filling shells* to be fired from guns; and this leads me to another subject well worthy the attention of Officers of both Services.

Most members of this Institution well know the interest I have long taken in the official experiments; and the lengthened series, in October and November last, at Eastbourne, would naturally have attractions for me. Seeing there round after round of heavy shells with gunpowder bursters fired against the fortification structures without producing any effective results on the masonry and concrete, I requested permission to try some shells loaded with cotton-powder, which was graciously accorded.

The result was exceedingly satisfactory. Three shells—a 64-pounder, 180-pounder, and 350-pounder—were loaded with the Government gun-cotton, and three similar ones with cotton-powder.

The Service gunpowder bursting-charges of these shells are respectively 7 lbs., 14 lbs., and 27 lbs. The bursting-charges of Abel's gun-cotton put into them were $4\frac{1}{2}$ lbs., 10 lbs., and 21 lbs., the last by very tight and careful loading. Of cotton-powder, the bursting-charges were 7 lbs., 14 lbs., and 24 lbs., the last shell (the 350-pounder) being loaded with broken fragments of small cartridges with paper wrappers on them, and the chamber of the shell not being completely filled for want of time, the approach of twilight necessitating the performance of the trials. However, its load proved ample for the work before it, which it performed with a completeness which left nothing to be desired.

The six shells were laid in pairs, side by side, on various sections of the target—these sections representing various styles of permanent fortification—the termination of the target being a large Moncrieff gun-pit.

The two 64-*pounder* shells were laid on the upper surface of the overhanging crest of the gun-pit, and the two 180-*pounder* shells on the concrete roof of the opposite extremity of the target, the gun-cotton shell being on the roof, which was formed of half-inch iron arch plate 7′ 2″ span, resting on iron girders (18 feet span), with $13\frac{1}{2}$ inches of brickwork, and from 2′ to 3′ 6″ of concrete over it.

The 180-pounder *cotton-powder shell* was on an adjoining portion similar in construction, except that there was no brickwork, but the whole thickness of roof was of concrete, varying from 3′ 2″ to 4′ 6″.

The *two* 350-*pounder* shells were placed on the thickest part of the roof, where the vertical section of the structure gives:—Brick arch 2′ 8″ thick and 14 feet span, with from 1′ $7\frac{1}{2}$″ to 2′ 6″ of concrete at top, the concrete thickening with the incline of the upper surface of the roof.

The whole series of six were *fired simultaneously by battery*, the ordinary Service electrical fuzes being employed for the ignition of the charges. *Only the* 350-*pounder cotton-powder* shell with its bursting charge of 24 lbs. effected *penetration* of the massive roof. The other shells all made "scoops" in the concrete of greater or less dimensions, proportionate to their bursters; the *largest gun-cotton* shell not making a crater of more than about 3 feet in diameter and some 15 inches deep.

The break-through of the roof by the 10-inch (350-pounder) *cotton-powder shell* was singularly complete, the quantity effect being of that exact character so valuable in experiments, and so seldom obtained. Above was a wide crater, some 6 feet in diameter, and below was an inverted crater about 5′ 9″ across, a hole of over 2 feet in diameter being punched clean through at the intersection of the two craters.

XIX. This first essay of cotton-powder in the military world, and before the public for military purposes, was so good a beginning, that I confess I have been hoping to be invited to further trials, and there is still within me, a lingering trace of "hope deferred." Of course, I knew when I made these trials, the first words which would rise to an artilleryman's lips:—"*Oh, you put your cotton-powder shells on the case-*

"*mate; the thing is to get them there.*" Of course it is; and my reply was as prompt: "*If you will let me have the guns, I will send them there.*" I am ready, whenever the opportunity is given me.

XX. In the present circumstances of cotton-powder, any further details of interest to put before you do not occur to me; and I think I cannot do better than conclude this necessarily imperfect essay with the wish that, if the storm of hostilities which has been so long lowering over the political atmosphere should burst upon the world, that the Executive of the Cotton-Powder Works may be found to be *not* the least useful nor the least *active* of Her Majesty's subjects; and that long before such events, the War Office will have recognized at least some of the merits claimed for cotton-powder, and have given it fair opportunities of demonstrating that superiority which is now claimed on its behalf.

The CHAIRMAN: I dare say there are some gentlemen present who will favour us with their remarks on this subject in its various sections—civil, military, and naval. For myself, I should very much like to hear a little more as to its applicability to naval warfare; first, as to its perfect safety below, and in handling it, next as to the certainty of ignition and the utmost power of elastic propulsion while in the gun, without any chance of bursting it, and then as to making certain that in the hands of men more or less skilled in handling these things we may never have a mistake; because in these matters a mistake on board a ship is a very fatal thing.

Mr. J. PONSONBY CUNDILL, R.A.: There are one or two questions I should like to ask. Did I understand the lecturer to say that the detonators are sent out with the powder?

Mr. MACKIE: No, certainly not.

Mr. CUNDILL: As I understand, the cartridges can be kept wet on board ship, or elsewhere, and those cartridges, or the powder itself, can be detonated in the same way that the Service gun-cotton can with the help of a certain proportion of dry. Then there is what is perhaps a minor point; the lecturer said that on the occasion of explosions there was a sort of dust-cloud in the air, which was probably some compound of baryta. From my slight knowledge of it, I should say he is right. Now that is not a dust-powder I should care much to go into and breathe, because it is rather a poisonous substance. Two or three months ago I was up at some carbonate of baryta mines near Keswick, and I found that some of the men complained of suffering a good deal from the dust of baryta in its various compounds, especially when roasted with carbon. They complained a good deal both in the mine and in the roasting of the fumes of this baryta. Of course, it is a minor question, but the lecturer seemed to insist upon its being innocuous, although those who have had practical experience of it, say that it is not. A great deal of stress was laid on the question of density. We must all admit that if you press a given explosive tightly, you get more force out of the tight compression than out of the loose compression. But the density, as I understand it, is equivalent to the weight; that is to say, supposing two equal blocks, one of gun-cotton and the other of cotton-powder, the cotton-powder will be the heavier one, and very naturally it should, because it has got that extremely heavy stuff, nitrate of baryta, in it. I do not see that the actual density is a proof that it is more powerful; it may be so, but I do not follow the reasoning that it is more powerful because it weighs heavier. And the same question comes in with regard to the cost. Of course you get more absolute bulk of gun-cotton in a pound than of cotton-powder, so that it is hardly fair to compare the price of three shillings for two pounds of cotton-powder, with the two shillings and sixpence for the gun-cotton. With regard to sporting purposes, gun-cotton has often been tried, as regards its use in rifles, down at Woolwich ranges. I have frequently heard say that it went on shooting beautifully for a time, and then perhaps a cap had accidentally some slight degree more of composition in it, and

irregularities took place. It was always subject to irregularity of shooting, and now and then the rifle burst. As regards the recoil, the lecturer said the recoil was easy. I understood him to mean there was less recoil. Now, we do not want to get less recoil in the gun. The large gunpowder gives more recoil than the *poudre brutale* which we used to use, and we argue it is better for the gun to get pushed back than to have all the blow absorbed by the metal, and no recoil at all.

M. Gustave Canet: I should like to offer a few remarks, more especially as I had recently the opportunity of witnessing the manufacture of cotton-powder at Faversham. The general features which struck me on seeing the works were these: firstly, the ingenious process of crushing the fibres of the gun-cotton into very fine powder; then the washing, or rather purifying, of the same; and, lastly, the addition to the gun-cotton of an equal quantity of nitrate of baryta to obtain the cotton-powder. Mr. Mackie, in his able lecture, has fully explained this, so that I shall not say much about it. A great deal is being said and written every day about the relative merits of gun-cotton and cotton-powder. It seems to me it would be much easier to settle that important question by experiments similar to those carried on in France some time ago by MM. L. Roux, directeur, and E. Sarran, ingéneur du Depot Central des Poudreries. These gentlemen wished to test the relative strength of several explosives. They found out experimentally—1st, the charge of each explosive necessary to burst shells as nearly identical as possible; 2ndly, the amount of heat disengaged on explosion; and, 3rdly, the relative proportion of permanent gases produced by the explosion. They found that nitro-glycerine, gun-cotton, picric acid, and picrates of potash and strontium followed the law given by M. Berthelot, viz., the strength of explosives is nearly proportionate to the amount of heat disengaged on explosion; but fulminate of mercury and picrates of baryta and lead did not follow that law. It is very highly probable that the law will apply to cotton-powder; consequently we must expect, according to the figures given by Mr. Mackie, that with cotton-powder we shall get half as much strength again as with ordinary gun-cotton. There is another point I should like to refer to. MM. Roux and Sarran found also that there is a greater probability of obtaining an explosion of what they called the first order when there is a greater mechanical resistance to overcome. For instance, they found that to burst a shell, 12 grammes (that is a little over half an ounce) of dynamite were required when the dynamite was put loosely into the shell; but that if the dynamite was put into a piece of paper, 3 grammes only were required in order to produce the same effect, showing that the simple resistance of a piece of paper would determine an explosion of quite another order in dynamite. They found exactly the same thing in gun-cotton, which they could hardly explode in its natural state, but they could obtain its explosion when packed tightly in a piece of paper, or in its compressed state, or when it is introduced into an inert substance which is afterwards crystallized, such as chloride of potash, and also when wet pressed gun-cotton was frozen. It seems to me that the mechanical resistance offered by cotton-powder is much greater than that by gun-cotton; consequently I should say the advantage would be again with the cotton-powder. All this could be easily settled by experiments, and it is highly important that such experiments should be made. It has been stated by a former speaker that the recoil of guns is greater with a slow-burning powder than with a "brisante" powder. I saw some time ago several eminent officers of a French experimental commission, and I asked them if they had remarked such a fact in their practice. They replied that the idea was quite new to them, and that in their experiments they found no difference at all in the recoil.

M. C. A. Faure: I should like to say a few words on the stability of gun-cotton, because that is the point we are to look to. We have the "fact" staring us in the face that gun-cotton is "*thoroughly* stable," but no Government will believe it. The English Government do not believe in gun-cotton; they use it, but dip it in water, to make sure of its safety. The French Government will not look at it, and therefore there appears to be very great difficulty in establishing the stability of the produce for naval purposes. This will warrant, I think, a few more words on the stability of cotton-powder, and the way it is purified at Faversham. Since gun-cotton has been introduced, there have been a great many accidents, which have burnt nearly as much gun-cotton as has ever been made use of, and no one will,

therefore, believe in gun-cotton unless it is kept wet. Now I am sure wet gun-cotton is almost useless practically, and we at Faversham have really started a new era in its manufacture, and claim to have removed this uneasiness on account of safety. Those who are initiated in the controversies that have taken place on the stability of gun-cotton will know well what I mean, and why it is necessary that there should be more proof before you ask the Navy to carry tons of dry gun-cotton in their ships. The impurities in gun-cotton are impurities that cannot be washed away; that is really the fact. The Company have spared no means for facilitating the investigation of the properties of gun-cotton, in order to get at the bottom of it. Mr. Mackie himself has been untiring in his endeavour to get at the inner properties of the material, and we have really come to this, that the impurities in the gun-cotton are impurities that cannot be washed away, and any process of washing them out is wrong. They must be decomposed within the cellule of the gun-cotton itself, and there is nothing but boiling it with ammonia that will do this, because this boiling destroys all the nitro-starch, nitro-sugar, and anything injurious that is within. If you boil it with ammonia, you reduce them all to water and nitrogen, &c. That is the principle of the performance, and to my mind it is the only thing that need trouble you. We have established a new way of doing the thing, which was not done before, and whether this produce will obtain a large success, will of course depend upon its own merit. As something has been said about carbonate of baryta, I should like to say, it is very likely that those who are in carbonate of baryta mines must be thoroughly saturated with the stuff. When they go for their food, they must have heaps of it about their hands, and they must eat it with their food. Carbonate of baryta, if taken inside the digestive apparatus in considerable quantities would be injurious; but if we merely breathe a few particles in the air, it is a very different thing, and one need not be much concerned about that. I should think gun-cotton with its carbonic oxide emanations is much more dangerous than that little carbonate of baryta in suspension in the air, because it takes very little carbonic oxide in the air to make it poisonous, but it will take a good deal of the particles of carbonate of baryta to make it poisonous if you merely inhale it. As to nitrate of baryta being not quite suitable from a chemical point of view, I for myself should have opposed the idea of putting nitrate of baryta in powder, instead of other nitrates apparently better suited, but we are bound to use it, because the nitrate of baryta for the same amount of oxygen, occupies the smaller volume. It does not matter to the miner exactly what is the weight of the powder he puts in the hole; what he wants to do, is to have the smallest hole possible. Often a very small bore-hole costs a great deal of money to make, and if you can reduce the holes only three inches in depth, those three inches are worth sometimes a shilling, and the powder is worth only threepence. That is an advantage. And then with regard to shells, if you can put more into a shell you have so much more effect. That is the reason why nitrate of baryta is valuable, and experiments have shown it to be so quite sufficiently, I think, to warrant the Company keeping to what they have got.

Mr. Mackie: I should have been pleased to have heard some opinions from Naval Officers present as to the use of explosives in a variety of ways, but, under the circumstances, I am very happy to deal with the questions which have been brought forward. The practice of sending out detonators with the powder is one which is totally objected to on every ground both by myself and by the Company. It is utterly useless to make a powder that is absolutely safe in itself if you are going to destroy that safety which you have made, by sending out the very thing with it which causes the explosion. I always recommend railways to send the detonators which are consigned with orders, in a separate van from the powder itself. As long as this powder is left by itself, it will stand any amount of ordinary blows or heat, but to mix up detonators with powder of a quality so safe as this, would be a very great piece of folly. Then again the powder can be exploded wet, but there is no use in keeping the powder wet. I think the saying of Cromwell, "Trust in Providence, "and keep your powder dry," is as good a maxim with regard to cotton-powder as it was of old, especially when you know that water takes away from the capability of the powder being immediately detonated, and that there is a risk in wet substances of their not being exploded at the time they are wanted; and the very fact that failure of detonation can arise from wetness, is a very proper barrier

to the use of wet powder. There is no doubt whatever that the Service gun-cotton often fails to explode at the right moment, through its wetness, or some cause connected with the system of damping it. Powder, to be serviceable on board ship, or on land, ought always to be available in the dry state, and the mixture of nitrate of baryta is as complete a dilutant to the gun-cotton as any amount of water that can be put there. It is just the same thing in its mechanical action as the grains of sand with gunpowder; and therefore, the cotton-powder, as you saw, was perfectly open to ignition without any chance whatever of explosion. With regard to the baryta dust, we know very little indeed about the poisonous effects of baryta, especially the carbonate of baryta. There are instances on record of people having been poisoned by taking carbonate of baryta into the stomach; and it is by introduction into the digestive organs only, so far as is known that baryta is injurious. In the mines where baryta is raised, and particularly when water from the vicinity of baryta mines is drunk, cases of poisoning from baryta would take place; but not from the effects of explosions of baryta in the cotton-powder. I have myself been present, when heavy charges have been fired, for days and nights together in close headings, and have fired as much as 30 lbs. at a time below ground; and on one occasion in a very close lead mine, without a particle of ventilation, we were firing charges from eleven o'clock in the morning to five in the afternoon, and I never suffered at all; and in no other case whatever have I ever experienced the least effect from the slight dust which comes from the cotton-powder. In fact, the great portion of the dust after an explosion arises from the limestone dust, or stemming, driven out from the disrupted rock. If you fire a charge in the open, you see very little result, except a mass of white steam. If you take the quantity of nitrate of baryta which there is in an ordinary mining charge of cotton-powder, and mix it up with the atmosphere of even a small heading, you will find it is diluted down to a very small percentage indeed, and that but next to nothing could be got into the stomach. In a dry heading, the dust very soon falls to the ground; and if the heading be damp, the dust is gone almost immediately. The smoke ordinarily vanishes away in less than a minute. It is not at all an unusual thing in a shaft of any depth to send down a fire-brazier to burn away the fumes of gunpowder. Certainly I would much rather work in mines in the smoke of cotton-powder for the whole day than I would for half that time in the smoke of gunpowder. The best proof is, that ever since we have been manufacturing the cotton-powder, the London and North-Western Railway Company have been using very large quantities for their tunnel in North Wales. They have 500 men employed there, and we have not had a single complaint. With regard to the density of cotton-powder, of course the addition of any merely heavy material would be of no value in the explosion; mere weight added would take off from the value of the density, the value of which really is in representing, as I intended it should, the weight of the actual available force of gas and carbon got into a given space, and which should be the indication of the power of the powder. But Mr. Faure has explained that baryta takes up more oxygen in the same space than any other substance that can be used, and therefore has the advantage in that way of giving more force to the gun-cotton; and I fully agree with him that the system which has been adopted in our works—and for which very great credit is to be given to Mr. Faure himself, who for three years has been my colleague, and whose services I am very proud to acknowledge—I agree with Mr. Faure, too, that nothing has ever been done for gun-cotton in the way of purification that approaches the system of destroying utterly by boiling with carbonate of ammonia the noxious qualities which were the bane of the old gun-cotton. I quite agree also in the necessity which M. Canet has suggested, that it is not by mere lecturers' arguments or theoretical talk that questions of the superiority of an explosive can be settled, and as I ended my essay with the expression that I hope the matter will have further attention, so I do most sincerely hope the opportunity may be given to us to show that the cotton-powder is what it is stated to be; that the road we have started on at any rate we can maintain; and if any one can beat us in it, we shall be very pleased to try our utmost to get again to the front.

The Chairman: May I ask whether you can see your way to producing a powder which would answer for great guns on board ship as well as on shore—one that

would give the greatest amount of propelling power, but gradually burning, and also igniting without the danger of an explosion?

Mr. MACKIE: I am much obliged to you for reminding me of those points. Gun-cotton, we all know, is sensitive to detonation, and however you may attempt to conceal it, a stronger cap than usual is liable to cause the destruction of the gun. What we have tried is to avoid detonation in the gun, and our trials have had in view to produce a gunpowder which would be a true gunpowder, and would give only a pushing force in the gun. In that direction we have succeeded in a very marked degree. Where the gun-cotton is reduced to an exceedingly fine powder, as it is with us, there is no degree of incorporation with other substances that cannot be effected, and I believe myself we could produce powder fit for any service whatever, from the smallest pistol up to the largest cannon. I do not say we could do it instantly, but we are on the right road to do it. It is simply a question of experiment and elaboration, but with such works as we have at Faversham, which are commercial works, the first consideration is earning a dividend for the shareholders. Therefore we are obliged to go on the road of blasting-powder because Governments are only single customers, and we cannot afford to spend the shareholders' money to produce a thing which has no general market. But there is no doubt whatever that if we are put to the test by any Government, we will do it. In that case I fully understand what you want is a gunpowder made from gun-cotton, which can be put into the hands of gunners to fire with perfect security, and that the guns shall not be exposed to risk of destruction.

The CHAIRMAN: I think the meeting will join with me in thanking Mr. Mackie for a very interesting lecture on a subject which concerns us all as naval or military men, not only at present, but for the future. We are, of course, much more interested with its Service-possibilities for the future than simply in the present commercial question. But we are still more concerned in the apparent prospect that there is of its great utility for our guns, both on shore and afloat.

LECTURE.

Friday, June 22, 1877.

General Sir WILLIAM J. CODRINGTON, G.C.B., &c., &c., Vice-President, in the Chair.

A MILITARY AND HISTORICAL STUDY OF SOME OF THE CHIEF THEATRES OF WAR IN EUROPE.

By Lieutenant-General Sir Richard Wilbraham, K.C.B., &c., &c.

I shall begin by tracing out the causes which have led to certain districts of Europe becoming on repeated occasions the scene of military operations on a large scale, and I shall then give a short description of some of these districts, illustrated by the most remarkable events in the wars of which they have been the theatre.

The districts in question are few in number, and their names will readily occur to all military men. Although there are few parts of Europe which have not been the scene of battles more or less numerous, it may almost be said that from the first introduction of modern strategy down to our own day, military operations on a grand scale have been confined to these districts.

There is an old saying that "History repeats itself;" and to no department of history is this saying more applicable than to military history. Of this we shall meet with several remarkable instances when we come to examine some of the chief theatres of war in Europe. I will only observe here, what every student of military history must have experienced, that in following out the movements of armies in recent wars, it is sometimes difficult to keep the thread of the narrative clear amid the confusing recollections of earlier campaigns on the same ground.

The causes which have led to certain tracts of country becoming more frequently than others the theatre of war are of various kinds. They may be summed up under the three following heads: political, geographical, and strategic. The first of these would scarcely seem to fall within the province of a lecturer on military subjects; but it is necessary to advert to it, inasmuch as political causes have not only given rise to most of the great wars on record, but have frequently determined the choice of the theatre of war. Thus, for instance, almost all the wars that have taken place in Italy during the last few centuries, and which have made the plains of Lombardy one of the chief battle-grounds of Europe, have been caused by the struggles of foreign powers, Spain, Austria, and France, not so much for

territorial aggrandisement as for political ascendancy. In like manner, it was a political cause, the adhesion of the Electors of Saxony to the cause of the Reformation, which made the plains of Saxony the chief scene of military operations in the religious wars of the seventeenth century. It happened, indeed, in both these instances, that the ground marked out by political considerations was such as a commander would have selected for its strategical advantages.

The other two causes, geographical and strategic, are usually found combined. They *may*, however, be separated, inasmuch as the geographical position of a country, especially if it be a weak country lying between two strong ones, will make it of necessity the battle-ground on which its powerful neighbours will fight out all their quarrels, even though it possess no natural strategic advantages. In such cases we shall find that the lack of such advantages has been as far as possible supplied by artificial means, as in the case of the Netherlands, which till within a comparatively recent period were guarded by a strong double, or even triple, line of frontier—or as they were called, barrier-fortresses, as a bulwark against the ambition of France.

Before entering upon a separate study of the several theatres of war which I propose to bring before you, I should wish to make a few general observations equally applicable to all.

There can, I think, be no doubt that strategic considerations are gradually losing much of their former weight in the selection of lines of military operations, owing to the introduction of new elements into modern warfare. In the first place, railways have entirely superseded the once valuable means of transport afforded by water communication; the course of a navigable river used frequently to determine the line of operation of an army, but campaigns are now too short, and the movement of armies too rapid to allow of even siege *matériel* being transported by so slow a means of conveyance. It is, of course, obvious that for *other* reasons the choice of a line of operations will always be materially influenced by the course of rivers. We shall find that the easiest if not most direct access into the heart of almost every country is along the valleys of its rivers. The means of communication, whether by rail or road, are usually more abundant while the river effectually protects one flank of the advancing army. France in her numerous invasions of the Netherlands has always advanced along the valleys of the Scheldt and the Sambre and Meuse, while in her turn she has been always invaded by the valleys of the Seine and the Marne.

But it is not only water communication that railways are superseding for military purposes; even the great military roads, such as the Simplon, the Brenner, and the Stelvio, constructed at an enormous expense with the sole view of facilitating the movements of troops, are now comparatively useless. Difficult passes, which within the memory of some among us have seriously impeded the advance of armies, are now *turned* by the construction of a railway; the increase of speed more than compensating for a considerable increase of distance.

I witnessed a striking example of this when visiting a few years since the battle-fields of the Franco-German war in Alsace. The small but strong fortress of Pfalzburg, a name so familiar to the readers of

Erckmann-Chatrian's "Le Blocus," was long the key of the Vosges. It commanded the only practicable road through that mountainous and densely wooded district. But the construction of the railway from Avricourt to Strasburg, which passes a few miles to the south of it, has so completely deprived it of its military importance that at the time I visited it it was being dismantled, and the dressed stone with which the ramparts were faced, was being carried off to repair the breaches of Strasburg.

Then again the multiplication of bridges—railway and other—together with the increased efficiency of pontoon trains, has made modern armies in a great measure independent of those fortresses which in the last century effectually commanded the passage of most of the great rivers, and narrowed the line of operations to two or three points. Every reader of military history will remember the strategic importance of such places as Augsburg and Ulm, and Torgau and Wittenberg, and other *têtes-de-pont* in the valleys of the Danube and Elbe.

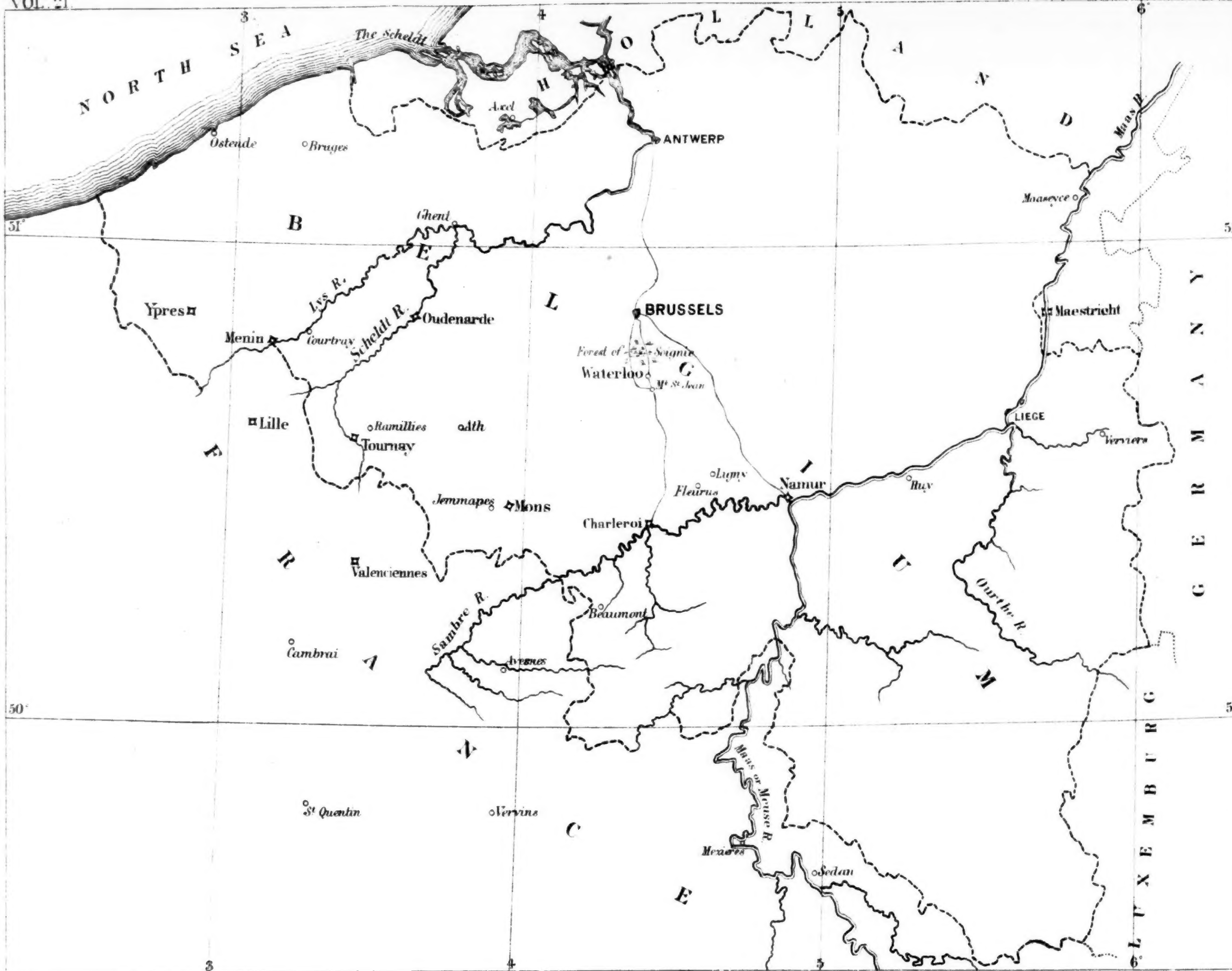
I need scarcely say that the military operations going on at this moment on the lower Danube, will throw much light on the value of a great river as a frontier under the altered conditions of modern warfare. But, as I stated in my lecture[1] on the war of 1828–29, the Danube presents exceptional obstacles to the advance of an invading army from the north.

Probably no better illustration of the former importance of rivers in influencing military operations could be found than the value set by the Duke of Wellington on the occupation of the bridges of Almaraz and Alcantara on the Tagus, in the campaign of 1809. In describing this campaign, Napier remarks that it is the Tagus which gives the key to the operations on both sides. From Toledo to the sea there were at that time not more than two or three bridges, and consequently the possession of these was of the utmost importance to either side. After being repeatedly won and lost they were destroyed, so far as their massive Roman construction allowed, and as Napier tells us, "Both French and English found cause to regret their destruction," so completely did it paralyze all their movements.

But it is not only as *têtes-de-pont* that fortresses have lost much of their former strategic importance. The enormous increase in the strength of modern armies enables them to *mask* even fortressess of the first order, which in the last century it would have been necessary to besiege and take before venturing upon a further advance. More than one of Louis the Fourteenth's campaigns in the Netherlands began, and *ended*, with the siege and capture of a single barrier-fortress, while *we* have witnessed the astounding fact that Metz with its garrison of more than a hundred and seventy thousand men—for Bazaine's army was to all intents and purposes a garrison—scarcely delayed for a day the advance of the Germans upon Paris.

The same cause, the numerical strength of modern armies, makes them also less dependent than formerly upon strong positions. With a front extending from four to five miles, or even more, there is little

[1] See Journal, vol. xx., page 692, *et seq*.


NORTH SEA
The Scheldt
HOLLAND
Axel
ANTWERP
Ostende
Bruges
Ghent
BELGIUM
Maaseyce
Maas R.
Ypres
Menin
Courtray
Lys R.
Scheldt R.
Oudenarde
BRUSSELS
Maestricht
Forest of Soignie
Waterloo
Mt. St. Jean
Lille
Ramillies
Ath
Tournay
LIEGE
Verviers
Ligny
Fleurus
Namur
Huy
Jemmapes
Mons
Charleroi
Valenciennes
Sambre R.
Beaumont
Ourthe R.
Cambrai
Avesnes
FRANCE
GERMANY
LUXEMBURG
Maas or Meuse R.
St. Quentin
Vervins
Mezieres
Sedan
51°
50°
3
4
5
6°
J. Jobbins

danger of the flank being turned; and what is now chiefly looked for in the choice of a position, is space enough to deploy the vast masses of troops brought into action. Those who have never gone over one of the great European battle-fields, such as Borodino, Solferino, or Gravelotte, can, I think, scarcely realize to themselves the extent of country required by an army of a couple of hundred thousand men to form in order of battle. In an enclosed country like our own, such a battle-field could scarcely be found, as we know from the difficulty of finding suitable ground even for our small Autumn Manœuvres.

The greatly increased range both of artillery and musketry, has also materially affected the suitableness of ground for military operations. Such a movement as the celebrated parallel march of the French and English armies before the battle of Salamanca would now be impossible; while on the other hand a mountainous country like the Pyrenees, which with the imperfect weapons of that day was so favourable to the movements of light troops, and where our Light Division in the last year of the Peninsula war gained so much experience and renown, would go far to neutralize the value of the improved weapons of the present day.

The recent improvements in artillery will probably greatly facilitate the impending passage of the Danube, for the Turkish fortresses of Widdin, Rustchuk, and Silistria, are now brought within range of the heavy Russian batteries on the opposite bank of the river.

It had been my intention to bring before you this afternoon, four theatres of war which have played the most prominent part in the military history of Europe, viz., the Netherlands, or Low Countries, the plains of Saxony, the valley of the Danube, and the plains of Lombardy; but I have found it impossible to compress them into a single lecture, and shall, therefore, restrict myself to the two first.

To begin with the Netherlands; the strategic features of this theatre of war are not so clearly defined as those of the others that I have named, it being, as I have already intimated, its position between the two great military powers of France and Germany, which has made it one of the chief battle-grounds of Europe. It has been the scene of countless sieges, and though the somewhat monotonous record of siege-operations is from time to time relieved by the brilliant episode of some memorable battle, such as Ramillies, and Oudenarde, these actions have seldom formed part of a combined plan of operations, but have usually been brought on by an attempt to relieve some beleaguered fortress. The battle of Ramillies was fought by Marshal Villeroy under the impression that Marlborough was about to invest Namur, and the battle of Oudenarde was fought by Marlborough to prevent the siege of Menin by the Duc de Bourgogne.

It will be unnecessary to give a detailed description of the military features of the Low Countries. As its name implies, the country generally speaking is low and flat. It is intersected with numerous rivers and canals, and studded with fortified towns. The sites of most of these towns were not originally selected with an eye to their military importance. Built for commercial reasons on the banks of navigable rivers, they were fortified for the security of their inhabitants in lawless and turbulent times, but since the beginning of the reign of Louis the

Fourteenth they have served as a bulwark more or less effectual against the ambition of France. The ill-advised demolition of the most important of these barrier fortresses by the Emperor Joseph, only a few years before the outbreak of the French Revolution, laid the whole country open to the invasion of the Republican armies.

The annexation of the Netherlands, first to Spain and afterwards to Austria, led to their becoming the scene of all the wars between those countries and France. And as France was generally the aggressor, especially during the long and warlike reign of Louis the Fourteenth, it was from the side of France that the invasions of the Low Countries mostly took place. From the base of the French frontier the chief lines of operations are by the valleys of the Scheldt and the Lys, and the Sambre and Meuse. The most important fortresses on these lines are Lille, Tournay, Mons, Charleroi, and Namur. This last may be considered the key to the Netherlands, commanding as it does the navigation of the Sambre and Meuse, together with the main lines of communication through that broad and open valley, the easiest mode of access into the heart of the country. Few fortresses in Europe are stronger than Namur, and few have undergone more frequent, or more obstinate sieges.

The country lying between Namur and Brussels has, as might be expected from its situation, been at all times one of the chief battle-grounds of Europe; almost every village throughout that district is a name well known to military men. Fleurus, without any very marked advantage of position, has in no less than four separate wars, been the scene of a general action; in 1662, in 1690, in 1794, and again in 1815. In the second battle of Fleurus, in 1690, Marshal Luxembourg occupied a prolongation of the position taken up by the Prussians on the 16th June, 1815, and in the third, 1794, the Austrians after their defeat by the French under Marshal Jourdan retreated to Mont St. Jean, the name by which, as you are aware, the field of Waterloo is still known in France.

The wars in the Netherlands acquire much additional interest from the number of eminent soldiers of all nations who have served with distinction in that country. I need only enumerate the following: Alva, Alexander Farnese, Turenne, Montecuculi, Condé, William of Orange, Marlborough, Eugene, Marshal Saxe, Napoleon, and Wellington, besides the two celebrated engineers, Vauban and Cohorn.

I may here remark that few countries afford so favourable a field for engineering talent as the Netherlands, not only from the number of its fortresses, but from the nature of the ground, which, being flat and unenclosed, admitted of being greatly strengthened by lines of earth-works connecting the rivers and canals by which it is everywhere intersected. Nowhere perhaps has this mode of defence been carried to such an extent. One of these lines constructed by Vauban was thirty-two miles in length, and so solid, that portions of it still remain.

I will now proceed to illustrate this theatre of war by an outline-sketch of some of the principal wars of which it has been the scene.

The first of Louis the Fourteenth's four wars in the Netherlands, which lasted only two short campaigns, was chiefly memorable from the fact of the French army having been commanded in the first campaign by Turenne, and in the second by Condé. The Spaniards, to whom the Low Countries then belonged, had entirely neglected the defences of the country, and offered scarcely any opposition to the invaders. It was ended by the treaty of Aix la Chapelle, in 1668, which among other strong places, ceded to France the fortress of Lille, which she has retained ever since, and which has greatly strengthened her northern frontier. Its fortifications were entirely remodelled by Vauban, who was appointed its first governor.

Louis' second war was against the Dutch, and here again the Netherlands necessarily became the theatre of war. In preparation for this war, the French army was re-organized, and a new system of exercise introduced by General Martinet, whose name has been handed down to posterity, not for the merits of his system, but for the strictness of discipline with which it was enforced. It is not to our credit that a force of 6,000 British, under the command of the Duke of Monmouth, took part in this war as the allies of France. Two of the French corps were commanded by Turenne and Condé; to the former of these the British contingent was attached, and thus Marlborough, who was then a captain in Monmouth's regiment, began his military career under Turenne.

The French army, 130,000 strong, advanced from Charleroi to the Meuse, and crossed that river near the fortress of Maestricht, which it masked. The Dutch army only mustered 50,000 men, of whom three-fourths were employed in garrisoning the fortresses. The other fourth, under the command of the Prince of Orange, afterwards William the Third, then only twenty-three, attempted to defend the passage of the Rhine at its junction with the Yssel, but in vain. It was only by cutting their dykes and flooding the country that the Dutch put a stop to the French advance.

I cannot enter into any details of this war, which lasted for six years; but it will not be without interest at the present time to learn that at the siege of Maestricht in 1673, our present mode of conducting approaches by zig-zags was used for the first time by an European army. It was introduced by Vauban, who borrowed it from the Turks, by whom it had been long practised. Montecuculi, in his memoirs, attributes to them the invention of this system, and adds that they never relieved their working parties, or the guards of the trenches, however long a siege might last. At the siege of Varna in 1828, and probably also at Silistria and Kars in 1854, they still adhered to this system, which is especially suited to their mode of fighting, and to the inertness of the Oriental character.

The war of which we are speaking was carried far beyond the frontiers of the Low Countries, the most instructive military operations being those in Alsace, between Turenne and Montecuculi, two masters in the science of war. Condé remained in command of the French army in the Netherlands till the death of Turenne removed him to a wider sphere of action. He was succeeded by Marshal Schomberg,

whom, remembering the part he took in the Battle of the Boyne, one is somewhat surprised to find fighting against William of Orange. It is but just to him to mention, that it was the revocation of the Edict of Nantes which made him exchange the service of France for that of her great opponent. A short lived peace was concluded in 1678. In 1683 Louis' aggressions led to a declaration of war by Spain. The most memorable event in this war was the siege of Luxembourg, one of the strongest positions in Europe, both naturally and artificially. It was conducted by Vauban, who was as successful in taking fortresses as in constructing them. The siege only lasted twenty-six days, which was attributed to the use of shells, then a recent invention. Vauban had the rare good fortune of testing the value of his own system of fortification, by having alternately to defend and to attack fortresses that he had himself constructed.

In 1688, on the invasion of England by William of Orange, France declared war against Holland, and in the following year an English auxiliary force was sent to the Low Countries under the Earl of Marlborough. We now come upon ground familiar to us. Marlborough found himself fighting almost on the same field as his great successor Wellington, but not at first with the same success, for the French, under Marshal Luxembourg, were more than a match for the allies. A battle took place almost on the field of Ligny, in which the latter were defeated with heavy loss.

In 1691, the state of affairs at home enabled William to resume the command of the allied armies in the Low Countries, and we find him on one occasion taking up the identical position occupied by Sir Charles Colville's division on the eve of Waterloo.

The siege of Namur in this war is full of instruction for engineers. I will only mention one curious incident. Cohorn was in command of a detached fort which he had himself constructed. The attack was conducted by Vauban, who succeeded in cutting off its communication with the place, and forced his great rival to capitulate. The only other events of importance in this war was the battle of Neerwinden, in 1693, in which William was defeated by the French under Marshal Luxembourg, with a loss in killed, wounded, and prisoners, of nearly 20,000 men. This was the completest victory that the French had ever gained in the Low Countries, and the severest defeat that William had ever experienced. The war continued however for four years longer, when it was closed by the peace of Riswyck.

The disputed succession to the crown of Spain, led to the renewal of hostilities in 1702, and again the Netherlands became the theatre of war. A British force of 13,000 men, under the Duke of Marlborough, was sent to Holland, and the interest now increases from the prominent part taken henceforth by our countrymen.

Marlborough's advance was made from the opposite quarter to that from which all the French invasions had taken place. The Dutch frontier was his base of operations, and he crossed the Meuse at Grave, transferring the seat of war from the narrow strip of country between the Rhine and the Meuse, into the Spanish Netherlands and the plains of Brabant. By a series of skilful manœuvres, he compelled the French

to fall back behind the lines they had constructed for the defence of the Netherlands. These lines were on a gigantic scale. They extended with scarcely a break, from the Scheldt below Antwerp, to the Méhaigne, near its junction with the Meuse, a distance of seventy-two miles, and consisted of a wide and deep ditch, with a rampart of respectable profile, "rendering credible," as a historian of the war remarks, "the records of the amazing works performed by the Roman "legions under Cæsar."

Time will only allow me to glance at some of the chief events of this ten years' war. The brilliant campaign of 1704, culminating in the great victory of Blenheim, belongs to another theatre of war. In 1705 the British army crossed the future field of Waterloo, and had an affair of outposts at the entrance of the forest of Soignies. In 1706 Marlborough gained the decisive battle of Ramillies. In 1708 by a bold and rapid flank march he surprised the French while in the act of crossing the Scheldt, and totally defeated them at Oudenarde. In 1709 followed the battle of Malplaquet, a decisive, but hardly contested victory; here Marlborough's brilliant military career comes to an end; a change of ministry took place in England, and in 1711 he was removed from the command. He was succeeded by Prince Eugene, and the British contingent under the Duke of Ormond was left for a while in Flanders; but in the following year England concluded a separate peace with France, and her troops were withdrawn. In 1713 the peace of Utrecht put an end to this long war.

The next war we have to record broke out in 1744, after an interval of thirty-one years. It consisted of five campaigns, in all of which the French army was commanded by Marshal Saxe. An allied army made up of British, Hanoverians, Austrians, and Dutch was assembled at Brussels for the defence of the Netherlands, but there was no chief of sufficient authority to command so mixed a force. The Duke of Cumberland was appointed to the chief command in 1745, a year memorable for the battle of Fontenoy, which, though disastrous to the allies, was honourable to the British troops, who bore the brunt of the action, and nearly made it a victory.

The Scottish rebellion in this year caused the hasty recall of the British auxiliaries, and though they were sent back in 1747, nothing memorable was accomplished, and peace was signed in the following year at Aix la Chapelle.

In 1782 the Emperor Joseph, as I have already stated, gave orders for the demolition of the barrier fortresses, an act which gave quite a different character to subsequent campaigns in the Low Countries. This measure was adopted partly from a short-sighted economy, and partly from a delusive idea in the mind of the Emperor that the marriage of his sister, the ill-fated Marie Antoinette, with the Dauphin, would render war between France and Austria improbable.

In less than ten years the French Revolution burst forth, and in the Spring of 1792 France declared war against Austria, and poured her troops into the Austrian Netherlands. This first invasion was unsuccessful. The three invading columns were driven back in disorder; but in the Autumn of the same year, the French, encouraged by successes

elsewhere, again invaded the Low Countries. They advanced in four columns, the right column by the valley of the Meuse upon Namur, the second by the valley of the Sambre upon the same point, the third under Dumouriez was to move upon Brussels by Mons, and the fourth was to descend the valley of the Scheldt. The column under Dumouriez decided the issue of the campaign by the victory of Jemappes, which made the French masters of the whole Austrian Netherlands.

All these advantages were lost in the following year by their defeat at Neerwinden, on the same battle-field where Luxembourg had defeated William exactly one hundred years before.

The British army now reappears on the scene of its former exploits: first, a brigade of Guards, then other regiments, together with a Hanoverian corps, the whole under the command of the Duke of York. It was in this campaign that the Guards by a gallant bayonet charge won the distinction of "Lincelles" upon their colours, while the 15th Hussars by an act of equal gallantry won that of "Villiers on Couche." The 14th, 37th, and 53rd regiments also distinguished themselves at the battle of Tournay.

In 1794, Pichegru was the French commander. The battle of Fleurus entailed the loss of the whole Netherlands to Austria. The retreat of the allies was hazardous; one corps under the command of the Prince of Orange in its march from Nivelles to Brussels crossed the field of Waterloo and took up a position in front of the forest of Soignies a little to the right and rear of that occupied by the British under Wellington. Its flank was however turned, and it had to fall back in haste.

We now come to the short but decisive campaign of 1815. After the occupation of Paris, the British army was cantoned in the Netherlands, with its head-quarters at Brussels, awaiting the result of the deliberations of the Congress of Vienna. The demolition of the barrier fortresses had left the frontier of the Netherlands so exposed, that steps were already being taken for the reconstruction of some of the most important of them under the superintendence of English and Dutch engineers, when the unexpected news arrived of Napoleon's escape from Elba.

The Low Countries had now to be defended against the most formidable attack they had ever been exposed to. Wellington with his usual foresight had examined the frontier the preceding year, and had made up his mind as to what ought to be done. No time was now lost in carrying out his plans, and the work was executed with such vigour that even before Napoleon reached Paris great progress had been made in the restoration of the fortifications of Ypres, Tournai, and Mons. The fortresses which defended the valley of the Lys, Menin and Courtrai, had been so completely demolished, that strong palisaded field-works had to be constructed between that river and the Scheldt to cover the approaches to Ghent.

Wellington fixed his head-quarters at Brussels; the Prussians advanced up the valley of the Meuse and occupied in force Namur and Charleroi, so as to command the valleys of the Sambre and Meuse. The frontier to be guarded was a flat and open country upwards of a

hundred miles in length from Namur to Ostend. It was of course impossible to prevent an enterprising enemy from breaking through this line at some point or other. All that could be done was so to dispose the allied army as to allow of its rapid concentration on any threatened point.[1]

The French army of invasion assembled at Beaumont between the Sambre and Meuse. On the 15th June it crossed the Sambre at and near Charleroi; the Prussians fell back in the direction of Namur, and Ziethen's corps took up a position at Fleurus, followed closely by the French; Blucher with his two other corps at the same time advanced from Namur, and took up a position at Ligny, equidistant between Namur and Charleroi, where he was joined during the night by Ziethen. His force now consisted of 78,000 men, and was in a position either to receive an attack, or to act upon the French right should they push forward upon Brussels.

Meanwhile the allied army under Wellington was moving from Brussels and the other places which it occupied upon the position of Quatre Bras, where it would be in easy communication with the Prussians at Ligny, and from whence the line of retreat upon Antwerp would be secure, should it be found impossible to maintain the positions either of Quatre Bras or of Waterloo.

The strategic movements adopted for the defence of the Netherlands are all that falls within the scope of my lecture. The great battles which brought that short and glorious campaign to a successful close, and gave to Europe the longest peace she had perhaps ever enjoyed, are too well known to need description.

It only remains to ask ourselves whether the Low Countries, which during the past two hundred years have been the constant scene of European warfare, are exposed to a like danger in future wars. The geographical position of the modern kingdom of Belgium, lying as she does between two such powerful and jealous, if not actually hostile nations as France and Germany, is certainly a dangerous one; and it has become all the more so now that the western frontiers of Germany have been advanced and strengthened, so as to leave to France no other outlet to the north and east except the narrow strip of the Duchy of Luxemburg.

Belgium is indeed a country which *invites* military occupation. It is intersected by a perfect network of railways, and abounds in resources of every kind. Its fortresses, even if their ramparts have not by this time been converted, like those of so many of the former strongholds of Europe, into shady boulevards, can no longer be called *barrier*-fortresses, for they would offer but a feeble resistance to a modern invasion; while its army, though large considering the extent and population of the country, and well disciplined and instructed, would

[1] The only point on which the Duke seems to have been sensitive as to his military reputation, was the imputation, sometimes ignorantly made, of his having been surprised at Waterloo. To this we are indebted for an interesting article in the "Quarterly Review," written by the first Lord Ellesmere, from data furnished him by the Duke himself.

run a great risk of being crushed by *one* of its powerful neighbours before *the other* could come to its rescue.

It is therefore evident, that if Belgium is to escape in the future the fate which has so often befallen her in the past—of becoming one of the chief theatres of war in Europe, it will not be to her own strength, but to the watchful jealousy of the other European powers that she will be indebted for that exemption.

Our next field, the great plains of Saxony, introduces us to operations on a much greater scale than those which we have hitherto been considering. Nowhere else, I believe, will so many celebrated battle-fields—some of them the scene of more than one decisive engagement—be found within the same compass. We are at once reminded of Lutzen, Leipsic, Dresden, Jena, and Bautzen, besides others of lesser note.

Some here present have perhaps looked down from the tower of the old castle of Leipsic upon the battle-fields of Leipsic and Lutzen. There are few panoramas, if any, more interesting to a soldier than this. In the far distance, on the western horizon, the spot is pointed out where Gustavus Adolphus fell in the hour of victory. It is still known as the Swede's camp. Immediately below you, at the very foot of the tower, stands the house in which the brave but ruthless Pappenheim died of his wounds on the morrow of Lutzen, while just beyond the castle wall you can trace at intervals among the houses and gardens of the suburbs, the narrow and sluggish stream of the Elster, in which the gallant Poniatowski, already mortally wounded, was drowned in the fatal retreat from Leipsic.

The plains of Saxony have on repeated occasions been the scene of some of the greatest military operations on record. Chief among these we may reckon the thirty years' war, the seven years' war, and the war of German Liberation in 1813. It would be difficult to find in Europe another tract of country so well suited to the movements of troops as these extensive plains; sometimes level, at others gently undulating. Far as the eye can reach on every side there seems nothing, not even a hedge, to impede the march of an army with its artillery and baggage, while a sufficient number of villages with substantial homesteads, lie scattered over the plains, to strengthen the line of battle whenever it might be found expedient or necessary to hazard a general action. In the immediate neighbourhood of Leipsic the plain is intersected by numerous small rivers, tributaries of the Elbe, which seriously interfere with the movements of troops, but elsewhere the country is, as I have already stated, open, and generally speaking, unwooded, except where it approaches the great chain of the Riesen Gebirge, when it becomes broken and difficult.

This theatre of war is very clearly defined by the natural features of the country. To the south it is shut in by the lofty and densely wooded range of the Riesen Gebirge, which projects like a huge bastion into the plain, and forms the northern boundary of the Austrian Empire. This range can only be crossed by a few mountain passes, almost impracticable for artillery, and easily defended. An army

advancing from east to west has, if it holds these passes, its left flank effectually protected from attack, or should it be unequal to forcing its way along its northern base, it can, as we shall presently see, move along its southern base, screened both from attack and observation, and by a shorter line turn the enemy's flank and debouch upon the plains to the westward of the line of the Elbe.

To the north and east the Saxon plains are covered by the Elbe, with its strong fortresses of Magdeburg, Wittenberg, and Torgau; but to the west—the quarter from which a French invading army would advance—they are comparatively unprotected, though the Saale and other smaller rivers which cross the line of operations at right angles afford strong defensive positions against an enemy not very superior in numbers. It is between the Saale and the Elbe that the most decisive battles have been at all times fought.

I need not describe with any detail the campaigns of Gustavus Adolphus on this field, which he did little more than cross in his victorious march to the south. After the terrible storming of Magdeburg in the Spring of 1631, the Imperialists, under the savage Tilly, fell back upon Saxony; Gustavus, who had landed in Pomerania in the preceding year, followed them closely, crossed the Elbe at Wittenberg, and marched unopposed upon Leipsic. Tilly had taken up a strong position in front of that town, but being urged by his generals to fight, he advanced a few miles to meet the Swedes, and on the field of Breitenfeld was fought, on the 7th September, 1631, what is better known as the battle of Leipsic, in which he was totally defeated.

In the following year the Imperial army was placed under the command of Wallenstein, who advanced into Saxony, sending orders to Pappenheim to meet him at Leipsic. This order is still to be seen in the Military Archives of Vienna, stained with Pappenheim's blood from his death wound received at Lutzen. Gustavus learnt through intercepted despatches, that Wallenstein had assembled his army at Lutzen. He at once advanced to meet him, and on the following day, 6th November, 1632, a battle was fought, which resulted in a glorious victory for the Swedes, though dearly purchased by the life of their hero king.

With the death of Gustavus the connection of the plains of Saxony with the thirty years' war may be said to end.

In the seven years' war, Saxony again became the theatre of war in consequence of her alliance with Austria. The earlier campaigns were indeed mostly carried on in Bohemia; but towards the close of 1757, the seat of war was transferred to the plains of Saxony and Silesia, where the battles of Rosbach, Breslau, and Leuthen, were fought, with varying success, but with the ultimate result of the cession of Silesia to Prussia.

It is not till we come to the wars of the first Napoleon, that we find these plains the scene of military operations conducted on the grandest scale, and on strictly scientific principles. It was their geographical position which made them the theatre of war, for they lay on the most direct and practicable route from the French frontier to the heart of Prussia and Russia. Leipsic, it will be seen, is the most important

strategic point; great military roads diverging from thence to the north by the bridges of Magdeburg and Wittenberg, to the east by those of Torgau, Meissen, and Dresden.

It is therefore in the campaigns of 1806 and 1812–13 that we may best study the strategic value of the plains of Saxony, as illustrated by the greatest modern master of the art of war, and it will now be necessary to describe the movements of the contending armies in some detail.

In the first of these wars, the French army only skirted these plains. The decisive battles of Jena and Auerstadt were fought just beyond the boundaries of Saxony proper, and Leipsic and Dresden were occupied merely as a precaution. But in the eventful campaigns of 1812 and 1813, the plains of Saxony and Silesia were repeatedly traversed from end to end by both the hostile armies in alternate advance and retreat.

The *advance* of what was proudly styled "the grand army" in 1812, was indeed, until it reached the Niemen, little more than a triumphal march, and Napoleon had no need to observe even the ordinary precautions of a passage through an unknown country, so completely had Prussia and Austria, who might have menaced his flanks, been crushed by the disastrous wars of 1806 and 1809.

The French *retreat* was also unopposed, for the disasters of the Russian campaign were so sudden and overwhelming, that there was not time to take advantage of the utter disorganization of the French army before it had fallen back into positions of comparative security.

It was not therefore till a new coalition, formed mainly through the efforts of England, had encouraged Germany to throw off the yoke of France, that Saxony and Silesia became the theatre of active operations.

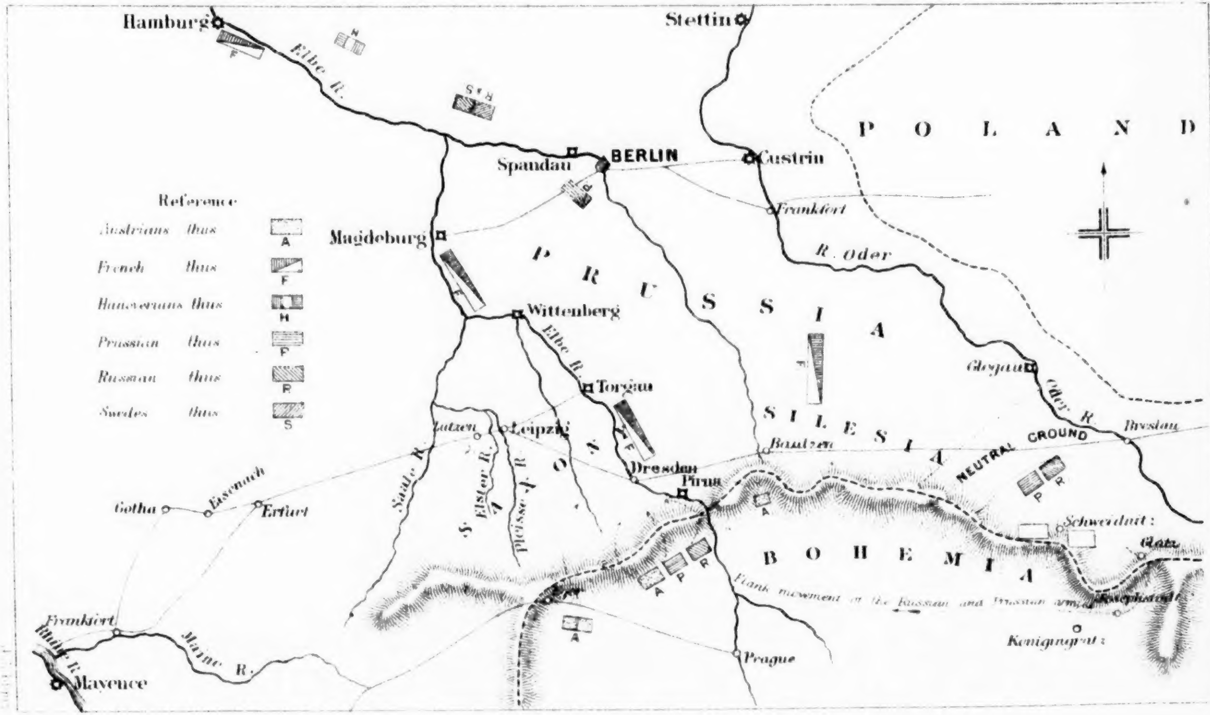
Our best authority for the war of Liberation is the well known work of the late Sir George Cathcart, who had the good fortune to serve throughout the whole of that war on the staff of his father, Lord Cathcart, British Commissioner with the allied armies, and under his guidance I will endeavour to give a short but connected account of the movements of the respective armies.

No campaign on record, either before or since, gives us a more instructive lesson in strategy than that of 1813. Europe has indeed seen still larger armies take the field, but never has a campaign been more obstinately contested, or success more evenly balanced until the final catastrophe at Leipsic.

The shattered remnants of the grand army had retired in the first place behind the Oder, then behind the Elbe, and had eventually fallen still farther back. In March the treaty of Kalitsch was signed between Russia and Prussia, Austria remaining neutral. But it was an unfriendly neutrality, and she only awaited the first favourable opportunity to join the coalition against France.

The allies formed their armies in Silesia behind the Oder, but advanced rapidly to the Elbe. They were too weak to undertake without risk so forward a movement, and reasons of strategy were all opposed to it, especially the vast distance to which it carried Russia from her reserves. But politically it was of the utmost importance to hold Saxony, so as to embolden Austria to declare herself.

PLAN SHEWING THE RELATIVE CIRCUMSTANCES AT THE RESUMPTION OF HOSTILITIES IN AUGUST 1813



The French army at this time (April) occupied Erfurth, Gotha, Eisenach, and Coburg. Napoleon's proposed line of operations was through Leipsic to Dresden, and thence to Breslau. Leipsic was the point of concentration of both armies, and therefore a general action at the very outset of the campaign was inevitable unless the allies gave way. But they would have had to fall back at least as far as the Oder, for the French garrisons in the fortresses on that river and on the Elbe amounted to 70,000 men, who might have acted on their flank, while they were closely pressed in front by Napoleon.

A battle was therefore hazarded on the 3rd May, on the already famous field of Lutzen, though the allies numbered but 90,000 to the French's 120,000. The result was indecisive, and it was expected that the fight would be renewed on the morrow, but during the night the French had made themselves masters of Leipsic, threatening the communication of the allies with Dresden. This, together with a lack of ammunition, forced them to fall back rapidly upon the Elbe, but they effected their retreat without confusion or further loss. It was not judged expedient to attempt to defend the line of the Elbe, so after destroying the bridges, they continued their retreat as far as Bautzen, with a view of covering Silesia and awaiting the arrival of Barclay de Tolly with reinforcements from Russia.

Napoleon crossed the Elbe on the 11th and 12th May, at and below Dresden. His numbers had increased to 140,000, while those of the allies had fallen to 80,000. He therefore confidently expected that they would continue their retreat till they had placed the Oder between them and him, and in this belief he had directed Ney to cross the Elbe at Torgau, and march upon Berlin, which he knew to be undefended, and the capture of which would, he calculated, bring Prussia to sue for peace. But when he found that they were resolved to make a stand at Bautzen, orders were sent to Ney to arrest his march, and to act upon the right flank of the allies.

Bautzen was a strong position well known in the seven years' war.[1] The left flank of the allies was protected by the mountainous frontier of Bohemia, protected also by Austrian neutrality. Their front was covered by the river Spree; but this latter advantage was neutralized by the marshy nature of the ground, which was unfavourable to the movements of cavalry, in which arm they were greatly superior to the French.

The battle began on the 21st, and continued for two days. The reverses of the Russian campaign had weakened the prestige of Napoleon, and victories like Jena and Friedland were no longer to be won from Russians and Prussians. Still the odds were too great, and seeing that it would not be possible to maintain their position till nightfall, the allied sovereigns on the afternoon of the second day reluctantly gave the order for a general retreat. It was none too soon, for half an hour's delay would have seriously compromised the safety of the right wing.

[1] During the battle the allied sovereigns took their stand on an old redoubt constructed during that war.

Again the retreat was conducted in perfect order, but instead of retiring, as Napoleon had expected, upon Breslau, they fell back upon the fortress and entrenched camp of Schweidnitz, about thirty miles south-west of the capital. The French at once occupied Breslau.

The position taken up by the allies was admirably chosen. Napoleon could not venture to attack them, for in the event of their entrenched camp being forced, the only line of retreat open to them was across the Austrian frontier; and the awakened national feeling of Germany would doubtless have led the Austrians to join them heart and hand.

Under these circumstances Napoleon committed what the result proved to be the fatal mistake of proposing an armistice. It was readily accepted. The gain of time, though valuable to Napoleon for the consolidation of his nearly raised army, was far more valuable to the allies. Reinforcements were hurrying on from the interior of Russia and Prussia, while every day's delay strengthened the wavering resolves of Austria. Before the armistice had expired, she had joined the coalition against France.

The plan of campaign adopted by the allies on the renewal of hostilities was on a colossal scale. The battle of Leipsic has sometimes been called "the *battle* of nations." The war of Liberation may with equal fitness be called "the *war* of nations." A combined force of 100,000 Russians and Prussians was to march out of Silesia, through the mountain chain which forms the northern boundary of Bohemia; move swiftly and secretly along its southern base, join the Austrian army on the Moldau, and thence act upon Napoleon's communications in Saxony in rear of the line of the Elbe. Meanwhile Blucher, with an army of 80,000 men, composed also of Russians and Prussians, was to hold Silesia, covering the great line of communication with Russia; while a third army under the command of Bernadotte, of about equal strength, but made up of Swedes, Russians, Prussians, and other Germans, was to cover Berlin, and in the event of the grand army succeeding in forcing the line of the Elbe, was also to cross that river and close in upon the enemy's left. About 10,000 men of this mixed force were partisan corps under enterprising commanders, such men as the famous Lutzow, the favourite hero of German patriotic song. It was about this time that Generals Moreau and Jomini, two of the first strategists of the day, joined the head-quarters of the allies, and the chief command was vested in Prince Schwartzenberg.

We must now see what dispositions Napoleon had made to receive this formidable attack. Notwithstanding the fearful losses of the Russian campaign, the army that he had brought together to retrieve his fallen fortunes, still outnumbered the whole force of the allies. The fortresses on the Elbe had been strengthened; the bridges repaired, and an entrenched camp had been formed at Pirna, where the Elbe issues through a narrow gorge from the mountains of Bohemia. But Napoleon could not bring himself to act on the defensive, though, with his communications so seriously threatened, this was his true policy. He ordered the advance of his main army upon Silesia.

To save Blucher from being crushed, the left wing of the allies moved rapidly forward from the Moldau under the screen of the Riesen Gebirge,

which not only secured them from attack, but concealed their movements from the enemy's watchful eye. Debouching upon the Saxon plains in rear of the Elbe by four difficult but practicable passes, they stormed the camp of Pirna, and invested Dresden. This well timed and well executed diversion, the greatest flank march probably on record, drew Napoleon back in haste from Silesia with the Imperial Guard, and he now confronted the allies with a force of 110,000 men. On the 27th August, a battle was fought under the walls of Dresden. The allies greatly outnumbered the French, but they occupied an outer and far larger segment of a circle, and of necessity left an interval between their left flank and the Elbe. Into this interval Napoleon thrust a body of 10,000 cavalry led by Murat in person, which doubled up the allied left wing and forced the whole army to fall back in haste with heavy loss. But for the broken nature of the ground, which impeded pursuit, and the subsequent false movement of Vandamme, which led to the surrender of his whole corps at Culm, they would not improbably have been forced to lay down their arms. As it was, they had effected their object, and Napoleon's bold plans for offensive warfare had been defeated.

I cannot do more than allude to Blucher's gallant defence of Silesia against the repeated attacks of a superior force, or to his brilliant victory at the Katzbach, which took place on the eve of the battle of Dresden. Left free by that battle, Napoleon again hastened to Silesia in the hope of overwhelming Blucher; but that gallant veteran showed unusual caution, and favoured by the nature of the ground, skilfully avoided a general action. Much discouraged by this failure, Napoleon once more retraced his steps to Dresden, where he was met by the news of the signal defeat of his northern army at Dennewitz.

Nothing now remained for him but to retreat; yet he clung with fatal tenacity to the line of the Elbe. Unwilling to loose his hold upon Saxony, he lingered on from day to day at Dresden, and took no decisive step till it was too late. It was no longer in his power even to concentrate his forces behind the Saale, and thus secure his communications with France; he found himself compelled to accept battle against a greatly superior force, and in a most unfavourable position, having a large town behind him with narrow streets, and a single bridge by which to retire, should retreat, as was only too probable, become necessary.

The description of battles or battle-fields does not fall within the scope of my lecture. The rout of Leipsic was so complete that Saxony was at once cleared of its invaders, and never since that memorable year have the Saxon plains become the actual theatre of war. Once indeed, within the memory of us all, they bid fair to be the scene of the great struggle between Austria and Prussia for the leadership of Germany, but the promptitude with which Prussia at once seized upon the passes of the Riesen Gebirge, and the supineness or blind confidence of the Austrian commander, averted the danger and transferred the seat of war into Bohemia.

Hard indeed has been the lot of the little kingdom of Saxony in the wars of the last three centuries. Her fertile plains have been trodden

down by the march of foreign armies, and her beautiful capital has been the prize of the victor in many a contest in which she had nothing to gain, and all to lose. Nor, if we study the map of Europe, does there seem much chance of her faring better in future wars. On whatever sides the great powers may range themselves in the coming struggle for which all Europe is arming; whether the North be arrayed against the South, or the East against the West, her central position and the strategic importance of the line of the Elbe, point to Saxony as the most likely battle-ground, and perhaps some here may live to see the Saxon plains the theatre of a war, conducted on a grander scale, and fraught with more momentous consequences than any that Europe has ever yet witnessed.

Evening Meeting.

Monday, April 30, 1877.

ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart, C.B., Vice-President, in the Chair.

EXPLANATION OF A METHOD OF PREVENTING CORROSION OF IRON AND STEEL, AS APPLIED TO NAVAL AND MILITARY PURPOSES.

By Professor BARFF.

I THINK it is desirable, before entering into a description of the processes which I have undertaken to explain to you this evening, that I should, for the benefit of those who are not acquainted with chemistry, go into the nature of the changes which iron undergoes when it is submitted to the action of oxygen gas. I feel this to be more important since my process has become somewhat generally known, and interested persons have applied to me to explain to them its nature and its various applications. I have found a very great difficulty in making those who are otherwise well instructed understand the process, from their ignorance of the chemical reactions which it involves, and of those, connected with iron itself, which it prevents. Many of you here present, I have no doubt, understand thoroughly all that I am now going to treat of, but there are also others who I most earnestly wish to make thoroughly comprehend this process, who have not got that preliminary knowledge, and who must have it to some degree, in order that they may be able to understand the principle of the process, and its applications to iron. I shall, therefore, take the liberty, Mr. Chairman, with your permission, of endeavouring to make my explanations more clear by the use of a few simple experimental illustrations.

Iron in perfectly dry air does not rust at all; that means to say that the oxygen of the air will not unite with it. I have here an illustration of this, for in this bottle is a piece of bright iron wire which has been placed there for some days. In the lower part of the bottle you will notice a thick liquid. It is called oil of vitriol, and it has the property of absorbing moisture, so that by it the moisture of the air in this bottle has been absorbed, and we speak of the air as being perfectly dry. You notice that the iron is not rusted at all. Now I have a similar piece of iron in a similar bottle, and this contains none of that liquid which is able to absorb moisture. The iron has been in the

bottle for exactly the same length of time, and you notice that it is rusted, for the air in this bottle is moist; that is to say, it contains water-vapour in suspension, just as does the air in this room. Now I take another piece of bright iron wire, and I make it red-hot in the flame of this lamp, and you notice that it is covered with a black film, and this film is an oxide of iron, analogous to that which is formed in smithies, where hot iron is beaten into shape on the anvil. Around the base of an anvil in any blacksmith's shop you will notice a number of scales lying about, which persons are generally accustomed to consider as pieces of iron which fall from the iron when it is beaten. They are not iron, but oxide of iron. Now, in the first instance, the oxide is of a reddish colour, and is known by the common name of iron-rust, and the other is black. Now, Gentlemen, bear with me for one moment. I have here in this bottle a green solution. It is a solution of what is ordinarily known by the name of green vitriol. Now, green vitriol is a compound of another oxide of iron with sulphuric acid. Certain substances are able to take away the sulphuric acid from this vitriol, and this oxide of iron, which is insoluble in water, is thrown down as a precipitate. I need not tell you the names of these substances which have this particular property. It is simply enough for me to show you the result. I now add some of this colourless liquid to the green solution, and you see a dirty green substance is precipitated. I will throw this upon a plate, and it will begin to change colour. It will pass from dirty green to yellow, of a more or less reddish hue. It is manifest that a change of some kind must take place in its composition, in order to produce this change of colour, and the change is caused by the fact that the oxygen of the air has united with it, and has changed it from the lowest oxide of iron into the highest. The composition of the dirty green precipitate is as follows: 56 parts by weight of iron and 16 of oxygen, and when it becomes yellowish-red the composition of that body is twice 56 parts by weight of iron, and 3 times 16 by weight of oxygen. That is to say, the iron has taken up half as much oxygen as it had before, and hence that oxide is called a sesqui-oxide. I have here in these two tubes some of this sesqui-oxide. In the one tube you will notice that the colour is bright yellow, and in the other that it has approached more or less to a greenish hue. The tube in which this greenish substance is, contains a piece of metallic iron, for into both tubes the same yellow substance was originally placed mixed with water; the iron in the one tube has commenced taking away oxygen from the sesqui-oxide, and is gradually reducing it to the state of the lower oxide. From this experiment you will perceive that the lower oxide of iron when it is in the moist state exposed to air, takes up more oxygen, and that in the moist state, when acted upon with iron, it gives up oxygen to the iron. You will now be prepared I hope fully to understand the process which takes place when iron rusts. Moisture must be present, then the oxygen of the air unites with some of the iron forming the lower oxide, the same as that which I have just precipitated from the solution of green vitriol, and this, when exposed to air, becomes the higher oxide, and this higher oxide in the presence of moisture gives

up some of its oxygen to the metallic iron, becoming the lower oxide again in part, and this absorbs more oxygen from the air, and so the process goes on continually until the iron gets oxidized through its substance, or, as we in common parlance say, rusts away.

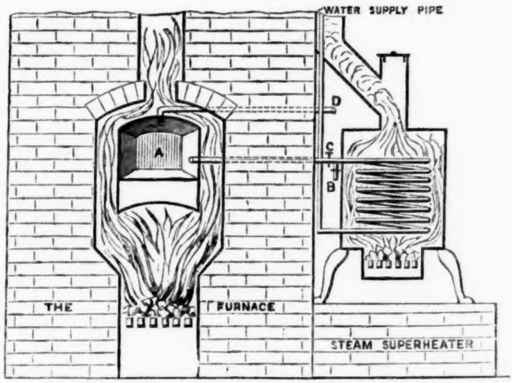
To return now to the oxidation of iron when heat is applied. If moisture be absent, only the black oxide is formed, and this black oxide is incapable of giving up its oxygen to iron, or of, under any circumstance, taking more oxygen from the air.

I have arranged some experiments to illustrate this I hope satisfactorily to you all. In a hard glass tube, connected with an apparatus consisting of a flask in which steam is generated, and which hard glass tube is heated throughout its length in a gas furnace, I have placed some iron filings and iron wire. I will pass the steam through this tube, and will collect in a bottle the hydrogen gas which is given off. You will notice that the iron filings and the iron wire have both assumed a dark-grey colour. This is owing to the conversion of their surfaces into the black oxide of iron, and the hydrogen gas you will see presently burn with its characteristic non-luminous flame. Now, if this iron wire be rubbed with the finger a portion of the black oxide can be removed, and if both wire and filings be exposed to moist air they will rust where the oxidation is not complete. In this bottle iron filings and wire, which were similarly treated a few days ago, have since been exposed to the air, and you will notice that they have rusted in part. I will now, instead of allowing the steam to pass directly into the glass tube, cause it to circulate through a coil of pipe which is placed in the centre of this little charcoal furnace, which is now perfectly red-hot. In its passage the steam will become dry or superheated. I will now let this steam pass into this other tube with which I have replaced the former one, which contains pieces of bright iron wire, and likewise some iron filings. The superheated steam will form on the surface of the wire a coherent and adherent coating, which will not rust on exposure to air. I don't mean to say that in the short space of time this iron has been exposed an absolutely perfect coating will be formed, for in practice iron to be rendered non-corrosive is usually exposed to the action of superheated steam from four to ten hours. In this case hydrogen gas is given off as in the former.

It is very interesting to me to know that several chemists, skilled in the application of that science to the arts, have endeavoured to effect, without success, what I, by a lucky chance, have been fortunate enough to accomplish. These gentlemen have related to me their experiments made, in some cases ten and in others twelve years ago, with a view to convert the surface of metallic iron into the black oxide, so as to prevent corrosion, and they have all told me that they failed at one particular part of the process, for they were not able to get a hard and coherent surface. It was my good fortune to make an observation in one of my experiments, after many many failures, which opened my eyes to the reasons why all my previous experiments had failed, and now tells me how it was that these gentlemen failed before me. My early experiments were made in an iron tube, about 10 inches

long by 2 inches diameter, the two ends of which were closed with iron caps, and into it, at each end, an iron pipe was fastened, the one for the passage in of steam and the other for the outlet of hydrogen. Into this small chamber pieces of iron were put, and the chamber itself was placed in an ordinary furnace. Steam was generated in a glass flask, and was allowed to pass into it for a short time, the iron chamber being heated to a red heat: I found that the iron was coated with black oxide, that hydrogen gas escaped from the exit tube, for I collected and burnt it. The black oxide was more or less adherent to the surface of the iron. Sometimes it was so pulverulent that it could be dusted off. At others it seemed more firm and coherent, but on exposure to air, the iron rusted and the black oxide was thrown off in powder or in flakes. On one occasion, on taking out a piece of iron, after it had been heated, from the iron chamber, I noticed that at one part there was a brownish-red tint upon it. This immediately gave me the idea that some of the red oxide of iron was produced on its surface, and that this was, in some way or other, mixed with the black oxide. The idea immediately struck me that, owing to the presence of moisture in the steam, some red oxide was first formed, that it was afterwards reduced to metallic iron by the hydrogen set free on the further action of iron on the steam, and that this reduced iron was eventually converted by the steam into the black or the magnetic oxide. Further observations tended to confirm and, I think, eventually to prove that this surmise of mine was correct. For I immediately had a coil of iron pipe made and attached to the iron chamber, between it and the ingress tube, and this coil was so constructed that it could be put along with the chamber into the furnace, and so be heated to a high temperature. The steam therefore passed slowly through the red or white hot coil of iron pipe previously to its coming in contact with the iron to be acted upon, and nearly the first experiment that I made with this new apparatus showed me that a hard coherent coating adherent to the iron could be produced. From that time to the present, the only difficulties which have attended the carrying out of this process have been of a mechanical nature, and have been step by step overcome, so that now, with almost absolute certainty, we can charge one of our furnaces and bring out all the specimens with a satisfactory coating. Sometimes we may have a few failures, and these all go to prove the fact that my theory, already stated, must be true. For, if the steam be turned into the chamber when it is not sufficiently hot to keep it in the state of dry steam, some of it gets condensed, water-vapour is formed, and this produces a result similar to that which I have explained to you as happening in our earlier investigations. I have to render thanks to my friend, Mr. Hugh Smith, for the help he has given me in carrying out this part of the application of my process. He has superintended the muffle in the treatment of all the experiments on the table. I have already mentioned to and shown you that the black oxide of iron is formed when iron is heated in atmospheric air; but, when it is so formed, it never adheres completely to the surface on which it is produced, and always on exposure to moisture comes

off, a coating of red rust being formed around and beneath it. Therefore, we found it essential and necessary to expel all atmospheric air from our heating-chamber before we allowed the entrance of super-



A. Muffle or Chamber, enclosed by Door. B. Test Tap.
C. Steam admission Tap. D. Hydrogen outlet Pipe.

heated steam. The diagram represents the muffle and superheater we now use. (See above, with letters and description.)[1]

I may say that there are two conditions absolutely necessary to success. The one is that no atmospheric air be present, and the other, that the steam be perfectly dry. The iron before being submitted to the action of dry steam must be perfectly clean, that is, it must have no spots of red rust upon it, for if it have, the results which I have previously explained to you will be produced in these particular spots, and after exposure to air rust will appear upon them. But you will see from the specimen to which I now call your attention, that this rust is perfectly circumscribed and does not extend laterally, nor is it formed under the coating of the black oxide. So that if some large article such, for instance, as a girder, were treated, and if many spots rusted after a time, owing to the causes which I have just explained, the strength of the girder would not in any way be impaired, as the rust would be perfectly localised and would not spread. This bar of iron was treated all over; with some difficulty I rasped off a portion of its surface, and the whole was exposed for a very considerable time through the late heavy rains on a lawn. You will perceive that the half from which the black coating has been removed has rusted completely, and that the rust has eaten its way a considerable depth into the iron, but the line of demarcation between the part not rusted and the rusty part is as well marked and defined as it was when the iron was first exposed. There is also in the black part of the coating a small spot of red rust, which ap-

[1] For further particulars, see *Discussion*.

peared shortly after its exposure, which has not in the slightest degree enlarged. That the acid-vapours of a laboratory have not any action on this coating of magnetic oxide is proved by these specimens before you, which for several months were kept in my laboratory where ten or twelve students are continually at work, and for six weeks of that time these pieces of iron were watered daily, except on Sundays, in order that the moisture might absorb the acid-vapours of the laboratory, and so corrode, if they could do so, the surface of the iron. You will notice that it is perfectly unchanged; but the places where the iron is exposed, through the intentional fracture of the iron, are all covered with red rust. Most of the specimens before you have been exposed for a longer or shorter time to the rain and dews of night, and I think you will see in all cases they have resisted more or less completely the action of the moist air. I need not take up your time longer by describing all the specimens before you, or by entering more fully into an explanation of the process. I believe I have already done it fully, and I believe in a way so simple that everyone, even the most unskilled in scientific matters, will be able to understand it.

Now, as regards its application to purposes in which you are all deeply interested. We will speak first about steam boilers and steam ships. Here is a piece of boiler plate, which after it was taken out of the furnace was rubbed with steel-wire cloth and emery paper, which has produced this sort of gloss upon it. It has been some time in the sink of the laboratory, and is, as you will see, perfectly free from rust. The black coating is firmly adherent to the surfaces. Suppose a boiler plate or an armour plate to have its holes drilled and to be oxidized, and suppose also that the rivets are oxidized as well, then when the plates are riveted together, the rivets being heated till they become soft, a proper pressure is brought to bear upon them, and this pressure may possibly interfere with the coating on the head of the rivets. I don't see well how it can interfere with it upon any other part of them. Next comes the caulking: and here, no doubt, the tools used would go through some of the black oxide and expose small portions of metallic iron, and this might rust. However, I must here mention that in one specimen before you, which I exhibited at the Society of Arts, a notch has been cut, and this was done by some one at the meeting in order to test its hardness. Now, it has been exposed ever since to the action of moisture, and this notch, as you will see, is not rusted at all, so that I fancy the iron is rendered non-rustible to a depth below the black surface, and this view is confirmed by the fact that almost every piece of iron from which I have removed the black surface only, without going into the iron below, has never rusted to any appreciable extent, and that the rust which forms upon it is not of the deep colour of ordinary rust, but is yellow, like certain well-known hydrates of the sesqui-oxide of iron, and that, moreover, this yellow substance can be wiped off, leaving the iron perfectly clean. This cannot be done to any piece of metal on which has been formed the ordinary iron rust. At present I am not in a position to speak with certainty, resulting from experiment, as to whether this process can be applied to ships or boilers, so as to prevent rust in every part. But

even suppose we cannot get over the difficulty resulting from the disturbance of the coat of oxide on the rivet-heads, it seems to me that very much will be gained by our being able to render the plates non-rustible, for it is manifest that it would take a very long time for iron rust to eat vertically into the head of a rivet. But I am sanguine enough to believe that this difficulty, which is not nearly so great as others which have been overcome in the perfecting of this process, will be vanquished likewise. One of the specimens before you has been placed in salt and kept in a moist atmosphere where the salt was alternately dry and wet for a very long time, and you will perceive that this black coating has been in no way affected. I do not, therefore, think that there is any fear of sea-water decomposing it. This small sample of black oxide was taken from the sea-shore, and it has never rusted I think that we have been able to prove that gun-barrels can be treated with it without injuriously affecting their surface. You will see before you several specimens, and of the effect produced upon them, you will be better judges than I am. Several Officers in the Navy have mentioned other applications which will be of inestimable benefit to various portions in the structure and furniture of ships. But here, again, Gentlemen, I need not take up your time by detailing them; for now you know the process thoroughly, you will be the best judges as to where it can be efficiently employed; for to all the bright iron or steel work in use amongst soldiers, whether helmets, swords, or scabbards, it may be applied with great advantage. For, as far as I know, it does not interfere with the strength or tenacity of the metal, and it most certainly hardens its surface. For stores of iron cannon-balls and shells, its application will be of very great advantage. An officer in the American Army told me the other day that the rusting of these materials of war is a source of considerable inconvenience. It is rather for you, Gentlemen, to point out to me the ways in which it can be made of use to you, than for me to mention them to you, and then I conceive it is my business to practically carry out your views, and see whether its application is admissible. Some time ago Mr. Perkins read, as I hear, a most interesting paper here upon his boiler-tubes,[1] in which he mentioned the strange results which had arisen from the action of water upon them at very high temperatures, and therefore under very considerable pressure. I am sorry to say that at present I am not able to throw that light upon the subject which I could wish to do, for a series of experiments which I am performing with specimens which he has given me are not yet completed. If by the time this paper is read I have completed them, I will write an account, which shall be appended to it. And thanking you very much for the kind attention you have given me, I shall now be happy to hear any remarks which you may desire to make, and to answer to the best of my power any question you may ask me.

Lieut.-Colonel CROSSMAN, C.M.G., R.E.: I should like to ask the Professor what the cost of this article (pointing) when coated would be?

Admiral of the Fleet Sir HENRY CODRINGTON, K.C.B.: I should like to ask also

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[1] See Journal, vol. xxi, page 777, *et seq.*

what would be the process by which the Professor would propose to make the inside of boilers secure in that way, because it would seem as if the large surface of the boiler would cool down even in superheated steam, so as to form moisture inside at the time. If we could succeed in protecting the inside of our boilers, it would be of the very greatest importance to us on board ship.

Mr. REECE: Might I ask if the process is applicable to steel?

Mr. DONALDSON (firm of Thornycroft and Co.): I have listened with much interest to the process which Professor Barff has described this evening, and I should like to ask a few questions with regard to it.

In the building of our steam launches we always endeavour, as far as possible, to preserve the bloom which appears on the plates as they come from the rolls, and we find that after years of use the parts protected by this bloom (which I believe is really the oxide produced by Professor Barff's process) are not in any way rusted. If this invention could be applied generally to the surface of one of these launches, it would be a very great protection.

The first question I should like to ask is:—What temperature is necessary in oxidizing articles by this process? If a large thin object, such as one of the hammered plates used in the construction of our boats, were put into a furnace and heated to a great heat, I should fear it would warp, and so render re-hammering and the consequent possible loss of the protective coating, necessary. I notice that all the articles exhibited by Professor Barff as having been operated upon are small and of such a form as would not be readily altered by heat.

The second question is:—When an object is oxidized, and a portion of the surface so protected is injured by abrasion, does the surrounding oxide act as a protection to the part abraded, as in the case of galvanizing, or will the rust eat through that part? I may say that in the French dockyards the plates used in the construction of small steam-launches are galvanized before being used; the rivets, however, are not so treated, as it is considered that the zinc on the surrounding parts affords them sufficient protection.

There is another question, not directly connected with the process, but which is to a certain extent suggested by the apparatus on the table, on which I should like Professor Barff's opinion. I should like to ask what is the condition of the steam in the tubes after leaving the superheater? Is it a *mechanical mixture* of hydrogen and oxygen, or is it a *chemical combination* of these gases? I have heard some very strange theories lately upon this subject.

Professor BARFF: In reply to the first question as to what is the cost of this article (pointing), our muffle at Kilburn is about the size of this tray, and stands about this height, that is 4 feet long by 3 feet wide, by 18 inches high, and you may judge how many of these articles can be put into it. They can be packed very closely indeed, though they must not touch one another. It costs 1*s.* 10*d.* per day for coke to fire the muffle and heat the super-heater to the proper temperature. Then there is a man's wages, so that if you distribute that cost over the number of articles that could be put into this sort of place, where the articles are small, it would be almost inappreciable for each article; of course the wear and tear of the muffle is to be taken into account as well. We have not made any estimate as to what that would be, but a muffle of this size, made of wrought iron, will cost somewhere about £70 or £80 with its superheater, and we hope that this muffle will last a considerable length of time, so that I think the cost would be very small. But we shall soon be able to give more accurate information as to the cost, for Messrs. Nettlefold, the great screw-makers, are going to put up an experimental muffle at their works at Birmingham for the very purpose of testing the cost before they bring it before the public, for their own use, and then we shall be able to give a definite statement as to the cost of screws, and from that we shall be able to form a pretty good idea as to what the cost of larger articles may be. But, at all events, the cost of firing is very little, and I do not think the cost of any particular article will be very appreciably raised. As to the inside of boilers, that is a question which really I am in the dark about at present, and I can only quote an authority. Some time ago Mr. Penn was good enough to give me an interview at Greenwich, and the thing was talked over there by Mr. Penn, Mr. Hugh Smith, Mr. Knight, Mr. Le Jeune, and myself. It was then said: "If you inject superheated steam into a

"boiler, and trust to the heating of your boiler by means of superheated steam, of "course you will get moist steam formed." But, as a practical boiler-maker, Mr. Penn said: "If you heat the inside and do not heat the outside, you will certainly cause unequal expansion and contraction, and so start your rivets." It was then suggested if we were to treat boilers at all, the way would be to put them into a firebrick chamber, and heat the boiler inside and out, and when the thing was at a sufficiently high temperature, to turn in the superheated steam, and to keep the boiler, as Mr. Penn said, if necessary a week under the action of superheated steam, both inside and out. That was his idea about it, but I hope in a short time I shall be able to give you the results of some carefully performed experiments upon that subject.

With regard to the application to steel, we have had difficulties to contend with here, and you will see them plainly. The temper of steel is judged of by its colour, and therefore with this blackened surface it would be simply impossible for us to tell the temper of steel by its colour. Hitherto my experience has brought me to this conclusion, that the blue temper of steel is quite destroyed by it, but that the yellow and higher tempers are not destroyed. We have a complete lock which we treated in this way, the springs of which seem to act, according to the opinion of those who are judges in such matters, just as well now as before they were treated; but the subject of steel and tempering steel is one that is occupying our attention very much indeed at present, and we are trying to devise a system by which we shall be able to temper the steel by definite fixed temperatures determined by the thermometer, instead of trusting to colour. I am sanguine enough to hope that we shall be able to arrive at such a point that this operation may be conducted on steel as well as iron.

Now as regards tensile strength, and as to fracture, I cannot tell you at present, but we shall be able to say something about that shortly. A gentleman present has been kind enough to undertake, at Messrs. Penn's works, tests on bars. He has only had two, and he wants three of each kind before he gives a definite opinion. All I know is the surface gets harder, and as far as one sees—we have one or two pieces of steel that have been done—they are looked upon with favour by those who have seen them, but I cannot speak more definitely upon the subject.

First of all, as to the bloom which appears upon the iron, that is no doubt black oxide. Wherever bloom is firmly and adherently attached to the surface of iron, as you say the iron does not rust, and that accounts for some of those facts I was mentioning in the early part of my paper, of the particular spots on armour plates or ordinary ship plates not rusting. Then, as to temperature. Any cast iron article may be heated to a very high temperature. Some of these bowls were heated to as high as 1,400 or 1,500 Fahrenheit. As to wrought iron; this is one of Russell's welded pipes, which was heated to a temperature of something like 1,100. These gun-barrels were kept at 850, so that our experience tells us that temperature must be divided into two classes. First, high temperatures for cast iron, and then, lower temperatures for different kinds of wrought iron and steel surfaces. We find that this cast iron specimen will stand a much higher temperature than that wrought iron one, but we have now got a coat which will not rust on exposure, and does not rub off by fair usage, and I think probably for gun-barrels that is quite sufficient. I think we may take a range of temperature from 650 to 1,500 Fahrenheit, the lower and longer for the wrought iron, the more rapid and higher for the cast iron.

Mr. DONALDSON: And an intermediate temperature for steel, I presume?

Professor BARFF: That very much depends upon the look of it. We have had a great deal of experience in these experiments, and on looking at articles we can form a sort of idea what temperature is required. We may be able to reduce that to a perfect system of results later on, but the workman who works for us has acquired this knowledge very rapidly, and I think that any workmen taught to do this would very soon become judges of the temperature required. Just, for instance, as in tempering saws and so on. It is simply a matter of experience. In dealing with various articles, such as those I have here, the temperature required would have to be learned by practice, and would soon be picked up by an intelligent person. The operation of firing up is so exceedingly simple that any one could do it who saw it done once or twice; and if any gentleman here is desirous of seeing the process we shall be very happy to show it him at our place. We make no secret of it. I

have here a diagram (see wood cut on page 927) which will explain the actual working to you. The superheating apparatus is simply a wrought iron chamber with fire bars containing a coil of iron pipe which, in our large superheater, is about 100 feet long and three-quarters of an inch in diameter, with a bore of a little more than a quarter of an inch. This pipe leads from a cistern placed 34 feet high as near as we can get it, so that we have our water under the pressure of an atmosphere. This water comes down and enters the lower part of the pipe. The pipe being red hot it cannot go any further for the first portions of it are converted into steam. This soon fills the pipe, the steam becomes superheated and the pressure prevents the water coming down, so that the water never gets more than a few inches probably into the lower pipe. There are two taps: one is for the test tap, and the man who manages the muffle turns on the tap, and if he sees any steam he knows the steam is not superheated. As soon as he hears the steam rushing out and cannot see it, he puts his hand to it, and if he can pass his hand quietly backwards and forwards through it, he knows the steam is sufficiently dry not to burn his hand, and, therefore, sufficiently dry to be turned into the muffle.

Captain BURGESS: Does sulphuric acid affect an article that has been coated, at all?

Professor BARFF: No; I have had a rod in oil of vitriol in a beaker glass kept at the highest temperature oil of vitriol will stand for from half to three-quarters of an hour, and have tested the oil of vitriol afterwards for the presence of iron by the most delicate of all tests, the sulphocyanide of potassium, and have not got the slightest trace of iron.

Sir HENRY CODRINGTON: You have exposed these things to salt and salt and water, but has there been any test with actual sea water, because that contains other things besides the chloride of sodium?

Professor BARFF: No; I have not exposed them to sea water, because I have had no sea water to expose them to. Here is a bottle containing some of the native black sand sent to me (from Taranaki, New Zealand) at the instance of Admiral Selwyn. This is from the sea shore, why, therefore, should this artificially formed oxide, which is identical in chemical composition, rust? I did not expose this piece of iron to the action of salt and water, because I had no doubt about it myself, but that I might be enabled to say it had been so exposed, because I received a letter from some one at a salt works saying that if their pans could be coated with this, it would be the difference between ruin and a fortune. I had this exposed to see if it were so. From all my experiments salt has no action upon it, but I argue, if this native oxide, which is of the same chemical composition as this, and yields to the same chemical re-agents, if this will stand the action of sea water for centuries, I do not see why this should not stand it as long as we may want it. I think that is a tolerably fair inference. There is one point in connection with this which is of interest, and that is the hardness of the surface. The rasp only polishes it, and does not abrade it at all.

The CHAIRMAN: I am sure we are all indebted to Professor Barff for his lecture, and for the very patient and clear manner in which he has answered the numerous questions put to him. One thing that has struck me very forcibly to-night, is that it is very rarely that we have a gentleman bringing before us, what to many of us is a very novel subject, without claiming a great deal more than Professor Barff has done. As a rule, inventors, (though we can hardly call Professor Barff one), claim a number of wonderful advantages, which, when put to a practical test, are found to be wanting. But we must all have noticed, with great pleasure, that Professor Barff in all the questions put to him, where he could not give a positive answer, gave a very cautious one. And he has also shown us that in these inquiries we seem to have the germs of a great many future lectures. He has told us that as to a number of the questions put to him, further experiments are required in order that he may be able to answer those questions in a satisfactory manner, and I am sure we shall all be delighted if, on any future occasion, when he has obtained some of the results he expects to arrive at, he will favour us with another lecture.

NOTE.—I have, since reading this paper, tried sea water and it has no action on iron coated by my process.

Evening Meeting.

Monday, May 7, 1877.

ADMIRAL E. G. FANSHAWE, C.B., President, Royal Naval College, Greenwich, in the Chair.

THE BEHAVIOUR OF SHIPS AT SEA.

By W. H. WHITE, Esq., F.R.I.N.A., Assistant Constructor of the Navy, Instructor in Naval Architecture, Royal Naval College, Greenwich.

ACCURATE and extensive observations of the behaviour of ships at sea are of comparatively recent date; their conduct may, in fact, be regarded as an indirect result of the ironclad reconstruction. Considerable anxiety was felt and expressed, in many quarters, as to the safety of ships burdened with great weights of armour; and it was generally assumed that they must roll heavily. These opinions were not shared by the designers of the ships, but they were so wide-spread that, unusual care was, from the first, bestowed upon the measurement of the angles of oscillation of ironclads, both absolutely and relatively to those of the unarmoured ships which sailed in company. The French led the way, our own Channel Squadron trials soon followed, and it was speedily shown that the popular belief was not well-founded, all, or nearly all of the ironclads proving at least as steady as the screw line-of-battle ships.

The observations thus commenced have since been continued, extended, and systematized in the Royal Navy and in the French Navy. Correct and simple methods of measuring the range of rolling and pitching motions have been introduced: and arrangements have been made for noting simultaneously the conditions of wind and sea under which those motions are performed. These developments are of great importance. Originally the observations were limited to the actual behaviour of a ship, but little attention being bestowed upon the attendant circumstances. So long as the original object alone was aimed at, these limited observations sufficed; for they enabled a trustworthy estimate to be formed of the absolute or comparative steadiness of a ship. But when it is desired to obtain from analysis of the recorded behaviour of completed ships, exact information which shall

be useful in designing other ships, the observations require to be as detailed and precise as possible.

One great object of the naval architect is to design ships which shall be steady and well-behaved; more especially ships of war which are to serve as gun-platforms. The modern theory of rolling, originated by Mr. Froude, and still receiving development at his hands, has enabled the designer to proceed with greater certainty in attempting to produce steady ships; in fact, it may be asserted that some of the steadiest ships, if not the steadiest, ever built, are those which have been constructed in accordance with the modern theory. Amongst ironclads the "Monarch, "Sultan," and "Devastation" are models of good behaviour; while the "Inconstant," "Shah," and "Raleigh," are unrivalled for steadiness among unarmoured ships.

It is undoubtedly true that in order to secure this superior behaviour in a sea-way, some of these recent ships have had their *stiffness*—or power to resist inclination under canvas—reduced considerably, as compared with earlier vessels. Great objections have been urged against this feature of the designs; but these objections have, I think, been already answered sufficiently, and I will only add two remarks respecting them. First, the reduction in stiffness was made advisedly, in order to increase the steadiness; and the French designers have followed a similar course. Their latest completed ironclads, the "Ocean" class, have no greater stiffness than our "Vanguard" class had before they were ballasted. Second, enlarged experience with bilge-keels has proved that these appendages may be trusted to limit the rolling of ships, having a moderate but sufficient amount of stiffness; and to place them on terms of equality, as to steadiness, with cranker ships having less powerful bilge-keels. With this experience as a guide for naval architects there is no probability that the stiffness of future ships will be diminished to the same extent as it is in some existing ships, designed before the steadying effect of bilge-keels was so well established.

It may fairly be claimed for the modern theory of rolling that it has now passed beyond the *provisional* stage. The highest authorities in this country, in France, Italy, and elsewhere, are unanimous in their acceptance of its principles; and the broad practical deductions therefrom have been verified by very numerous observations of the behaviour of ships of all classes. Some subordinate, but not unimportant, branches of the theory are still in the region of discussion; but the progress already made by Mr. Froude, and those who have followed him, makes further progress probable, provided only that the necessary *data* are obtained.

Our assurance of the general soundness of the teachings of modern theory is greatly strengthened by their agreement with the observations already made by naval Officers; and all who are interested in the study of naval architecture gladly acknowledge the obligation. In doing so, however, a fresh appeal must be made to sailors for aid in a department peculiarly their own. Recorded observations have considerable value; but they are not all of equal value, nor do they furnish all the information required. Already the application of the

modern theory in ship design has done much to improve practice, but the problem to be solved is clearly one which pure theory cannot deal with satisfactorily. Under certain assumed conditions of sea, for example, it is possible to predict, with close approximation to the truth, what the behaviour of a certain ship will be; and Mr. Froude has done so in many cases. But observation alone can determine what are the actual conditions of a seaway, how closely the dimensions and speeds of deep-sea waves approach to those which the accepted theory recognises, what are the worst conditions to which a ship is likely to be subjected, and how nearly her behaviour under those conditions corresponds to that deduced from theoretical investigations. In short, further progress with the theory of rolling and pitching, as well as with the work of designing ships which shall be steady and well-behaved, largely depends upon the observations which naval Officers alone can make.

It is often said that great advantage would result from some service at sea on the part of naval architects; and this view of the matter is doubtless correct. But, on the other hand, it must be admitted that no naval architect, in practice, can devote to the performance of service at sea the considerable amount of time which, from the circumstances of his service, the naval Officer spends afloat. And, therefore, I say again, naval architects must look to naval Officers for further extensions of knowledge respecting the actual conditions of a sea-way, and the actual behaviour of ships. Nor will they look in vain, I feel confident, when naval Officers become more interested in the subject, and obtain an intelligent acquaintance with the chief deductions from the modern theories of deep-sea waves and the behaviour of ships. The full discussion of these theories involves high mathematical reasoning, but the deductions which have the greatest practical interest admit of simple explanation or illustration; and I have already had the pleasure of seeing some beneficial results, in the form of improved observations, follow attempts to make clear the fundamental principles to which I more especially invite attention this evening.

First: as to wave-motion in the deep sea.

In my remarks on this subject I shall use the following terms :—

(1.) *Length* of waves; the distance from crest to crest, or hollow to hollow, measured in feet.

(2.) *Height* of waves; the height (in feet) from hollow to crest.

(3.) *Period* of waves; the interval elapsing between the passage past an observer who is stationary of two successive crests or hollows. The period is usually measured in seconds, and may be defined as the interval occupied by a wave-crest in advancing a distance equal to the length of the wave.

(4.) *Speed* of waves; their velocity of advance, usually expressed in feet per second.

Let it be supposed that a *single series* of waves is being observed, successive waves being of identical form; the accepted or trochoidal theory leads to the following conclusions :—

(1.) That the *profile* of the wave (its section by a plane at right

angles to the ridge) is a trochoid; and that this wave-form travels onward, often at enormous speed, while individual particles of water in the wave revolve in circular orbits, contained by planes perpendicular to the wave-ridge.

(2.) That the disturbance caused by the passage of a wave extends to a great depth, and affects a great mass of water, all the particles affected moving in circular orbits, the diameters of the orbits decreasing rapidly as the depths of the particles below the surface increase; but the speeds of rotation decreasing according to the same law as the diameters, so that each particle completes its circle in the same time. This interval equals the *period* of the wave. At a depth below the surface equal to the length of a wave, the diameters of the orbits of particles is less than one *five-hundredth* part of the diameters of particles lying on the upper surface.

The following are approximate rules:—

$$\text{Length of wave (in feet)} = 5\tfrac{1}{8} \times \text{square of period (in seconds)}$$

$$\left.\begin{array}{l}\text{Orbital velocity of particles}\\ \text{on surface of wave.}\end{array}\right\} = \frac{64}{9} \times \frac{\text{Height of wave.}}{\sqrt{\text{Length of wave.}}}$$

(3.) That the speed of advance of the wave-form depends upon the *length* of the wave, and is independent of the height.

Approximately—

$$\text{Speed of advance (in feet per second)} = 2\tfrac{1}{4}\sqrt{\text{Length.}}$$
$$\text{,, \quad ,, \quad (in knots per hour)} = 3 \times \text{Period.}$$

(4.) That the limiting ratio of height to length in an ocean wave is that of the diameter of a circle to its circumference (7 to 22 nearly). When this limit is reached the profile of the wave becomes a cycloid, and the wave is on the verge of breaking, its crest becoming a sharp ridge.

The fact that the apparent advance of waves is one of form *only* is well known. A log dropped overboard from a ship, past which waves are racing at great speed, is not swept away, as it would be on a tide or current, but simply sways backwards and forwards as successive waves pass.

It is possible by means of a simple apparatus to illustrate the rapid advance of wave-form which may accompany oscillatory or

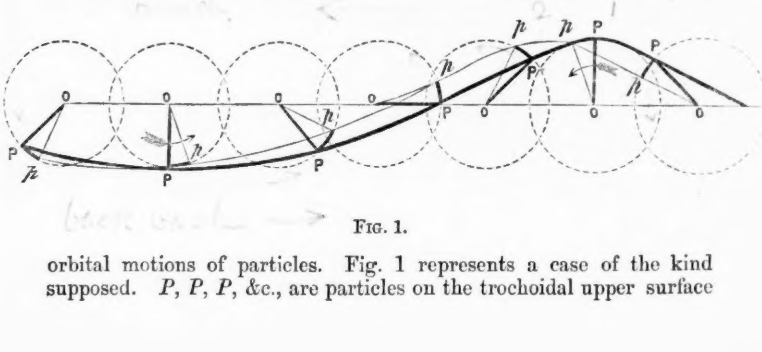


FIG. 1.

orbital motions of particles. Fig. 1 represents a case of the kind supposed. *P*, *P*, *P*, &c., are particles on the trochoidal upper surface

of a wave, the corresponding positions of the radii of their orbits being $o\,P$, $o\,P$, $o\,P$, &c. The wave is advancing from right to left. Suppose all the radii to turn through equal angles $P\,o\,p$, $P\,o\,p$, &c., simultaneously: then the points p, p, p, &c., will determine a curve which is clearly the same trochoid as formerly occupied the position $P\,P\,P$, and consequently the motion of rotation of the particles has brought about a motion of advance of the wave-form. At the crest, particles move in the direction of the wave-advance; at the hollow, particles move in the contrary direction.

Similar motion of advance in the wave-form may be produced by simple *vertical* oscillations, instead of orbital motions of particles. This was the earliest theory of wave-motion, which is now abandoned in favour of the trochoidal theory.[1]

Probably the most important deduction from the trochoidal theory has yet to be mentioned, viz., that the orbital motions of the particles in a wave produce notable variations in the *direction and magnitude of fluid pressure.* Each particle is subjected to the action of centrifugal force, as well as the force of gravity; and the resultant of these two forces deter-

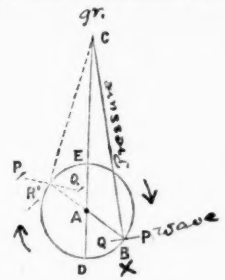


FIG. 2.

mines the direction and magnitude of the pressure on that particle. In Fig 2, let B be a heavy particle, revolving in a circle of which A is the centre; let the line AB represent centrifugal force, and AC drawn vertically represent the force of gravity, then BC represents the resultant pressure; and if B lies on the upper surface of the wave, that surface will place itself perpendicularly to CB, in the immediate neighbourhood of the particle B. It will be seen that the magnitude and direction of the resultant pressure (CB) change according as B moves in its orbit. At the hollow and crest the resultant pressure acts vertically; but at any intermediate position its line of action is inclined to the vertical; CR_1 showing that line when the particle is at R_1, and similarly for any other position.

Suppose a tiny raft, with its mast (as shown in Fig. 3) to replace the particle, and to float on the surface of a wave. Its mast will

[1] An apparatus was exhibited to illustrate each theory during the delivery of the lecture.

always coincide with the direction of the resultant pressure; and the consequent motion will resemble that of a pendulum. At the wave-hollow, the mast will be vertical; as the wave passes, and the raft

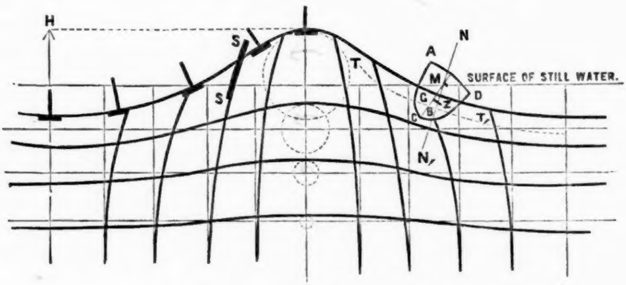


Fig. 3.

rises higher on the slope, its mast will become more and more inclined away from the vertical; near the mid-height of the wave the inclination will reach a maximum, after passing through which it will decrease gradually, until at the crest the mast is once more vertical. The range of inclination, therefore, depends upon the *maximum wave-slope*, which is governed by the ratio of the height to the length; and the rapidity of variation in the direction of the fluid pressure is governed by the *wave-period*. A single swing of the mast occurs during the half-period of the wave.

An observer standing on this raft would be so influenced by its motion that, to him, the mast would appear to keep truly vertical, and the raft to remain perfectly steady, while it might be rolling through an arc of say 15 or 20 degrees once every four or five seconds. A pendulum hung to the mast would also be affected by the wave-motion. and would coincide in direction with the mast. Moreover, if the observer attempted to estimate the height of the waves under these circumstances, the tangent to the wave-slope at the place occupied by the raft would appear to be horizontal, and in some cases the apparent height might be about *three times* the real height.

No ship exactly fulfils the conditions assumed for the raft, but all ships floating amongst waves are subjected to somewhat similar variations in the direction and magnitude of the fluid pressure. The importance and extent of these variations depend upon many circumstances; the form and magnitude of the ship, her course and speed relatively to the waves, the dimensions of the waves, their proportions of height to length, &c. It would be idle to attempt any discussion of these circumstances in the limited time at my disposal; suffice it to say, therefore, that for every ship, rolling amongst waves of any assumed dimensions, the resultant fluid-pressure impressed upon her will pass through a series of variations in direction and magnitude during the passage of each half-length of the wave—that is

to say, during the half-period of the wave. If, at any instant, the direction of the line of action of the resultant pressure could be determined, that would be the "virtual upright," towards which the ship would tend to move, if her masts did not coincide with it; just as in still water she would tend to return to the vertical if inclined from it. And if all the positions of the "virtual upright" were known, each of them would be normal to a surface, termed the "effective wave-slope." This effective slope may differ more or less from the upper surface of the wave, but it will be sufficient for our present purpose to consider the two as identical.

In Fig. 3 (right hand side), a ship is shown in cross section; the instantaneous position of the virtual upright is indicated by NN, and the masts of the ship are inclined to NN, at an angle GMZ, G being the centre of gravity. GZ is drawn perpendicularly to NN, and instantaneously the righting moment tending to bring the masts into coincidence with NN, is given by the equation.

Righting moment = apparent weight of ship × GZ.

The apparent weight of the ship would be less than the true weight in the upper half of the orbit, and greater than the true weight in the lower half.

The preceding brief statement contains the fundamental principle upon which Mr. Froude based his investigation. According to the accepted theory, a ship is no longer supposed to be set oscillating because of the shocks of waves upon her sides, or because the wave-surface has a steep slope, and heaps up water on one side as compared with the other side; these and all other of the earlier hypotheses are discarded, for they do not represent the facts of common experience. Vessels often roll heavily in a long, smooth swell, where the slope is almost imperceptible, and where no sensible shock is delivered against the sides. Out of the many cases in point, let one of the most recent be taken. When the "Dreadnought" ran outside Milford Haven for a preliminary trial of her engines, she encountered a long, smooth swell, which made her roll through quite ten degrees on either side of the vertical, to the great surprise of many on board. Afterwards, on her passage round to Portsmouth, this same ship met with very bad weather, and behaved remarkably well, scarcely rolling at all. On the old hypotheses such occurrences would be almost inexplicable; viewed in the light of the present theory they are easily explained.

The following appear to be the conditions governing the behaviour of ships among waves:—

(1.) The *period of still water oscillation* of a ship; *i.e.*, the time occupied by her in making a swing (say, from starboard to port) when set rolling in still water.

(2.) The magnitude of the *fluid resistance* to her motion; a measure of which is afforded by the rapidity with which she is brought to rest after being set rolling in still water.

(3.) The dimensions and proportions of the ocean waves encountered; also their speed and direction of approach to the ship.

Over the first and second of these conditions the designer of a ship can usually exercise considerable influence, but not in all cases. The

still-water period depends chiefly upon the *stiffness* (or "metacentric height") of a ship, and upon her *moment of inertia*, which is governed by the distribution of the weights, in relation to the centre of gravity. Other considerations unconnected with the period of oscillation have a great influence upon the distribution of the weights; and consequently naval architects have chiefly influenced the period by changes in the *stiffness* of ships. Reduction in stiffness lengthens the period: increase in the moment of inertia has the same effect.

General experience confirms the teachings of theory that, on the whole, the ships with the longest still-water periods are the steadiest in a sea-way. Out of the many cases on record take the following:—

Squadron of 1871.	Approximate still-water periods.	Mean Arcs of oscillation.
	Seconds.	Degrees.
"Lord Warden"	5 to 5½	62·
"Caledonia"		57·
"Prince Consort"		46·
"Defence"		49·
"Minotaur"	7 to 7½	35·
"Northumberland"		38·
"Hercules"	8	25·

French Experimental Squadron of 1863.	Approximate still-water periods.	Mean Arcs of oscillation.
	Seconds.	Degrees.
"Normandie"	5 to 5½	43·6
"Invincible"		41·4
"Couronne"	6	37·7
"Magenta"	7 to 7½	36·
"Solferino"		35·

Detached Squadron of 1875.	Approximate still-water periods.	Mean Arcs of oscillation.
	Seconds.	Degrees.
"Newcastle"	5	29·6
"Topaze"		22·6
"Immortalité"		20·
"Narcissus"		19·6
"Doris"		18·7
"Raleigh"	8	5·8

It is not always possible, however, to secure a long period of oscillation in combination with other and more important qualities. In such cases considerable steadiness may be secured by the use of deep *bilge-keels*. The well-known trials made by Mr. Froude with the "Greyhound" and "Perseus" furnish the most complete evidence of the usefulness of deep bilge keels: for the "Greyhound" thus fitted accumulated only about *one-half* the amount of rolling which was per-

formed by the "Perseus," the two ships being brought to almost identical conditions apart from the bilge-keels. The "Devastation" is another case in point: her still-water period is only $6\frac{3}{4}$ seconds, or 25 per cent. less than that of the "Sultan;" but the deep bilge-keels of the monitor helped her so greatly that in the trials off Berehaven she compared very favourably with the "Sultan;" and in her subsequent service she has given great satisfaction. One other case of a very different kind may be cited; that of the cable-ship "Faraday," built specially for laying submarine telegraph cables. She was required to be very steady in a sea-way; but her proportions and stowage were scarcely such as could be trusted to secure the desired quality, and deep bilge keels were fitted at the suggestion of Mr. Froude. Their effect has been most marked; and even in very severe weather the ship has been so steady that all the delicate operations of laying, splicing, under-running, &c., the cables have been continued.

It will be understood that the fuller recognition of the advantages of bilge-keels in no way lessens the force of the arguments in favour of giving to ships the longest period of still-water oscillation, compatible with other conditions of the design. But in some ships (as for instance in vessels of the central citadel type with great proportionate beam), it is almost impossible, by changes in form alone, to secure slowness of motion; and then bilge-keels are most valuable. In smaller classes of ships also wherein the moment of inertia is unavoidably small, and there is a necessity for a considerable amount of stiffness to carry sail, the still-water period cannot be made long, but by means of bilge keels, rolling may be considerably lessened. Even in slow-moving ships, like the "Shah," which would be steady under nearly all conditions of sea without bilge-keels, such keels have been added, and will doubtless be found of value. The experiments made in the "Greyhound" disposed of one objection to deep bilge-keels, viz., that they would cause a sensible or serious loss of speed; and henceforward the depths of these keels will probably be made as great as possible, the limits of size being imposed by the docks which a ship has to enter, or other conditions incidental to her service. In the "Greyhound" the experimental bilge-keels were $3\frac{1}{2}$ feet deep, a most unusual depth in proportion to the size of the ship, and exceeding by a foot the depths usually fitted to the largest ships.

Vessels with low freeboard, such as monitors, or with projecting armour shelves, stand less in need of bilge-keels than vessels of ordinary form, because the immersion of the decks, or the immersion and emersion of the armour-shelf, develops a considerable amount of resistance. The shape of the immersed part of a ship also influences the relative usefulness of bilge keels. A "full" ship with round, approximately cylindrical bottom, and with comparatively small surfaces of deadwood, would derive greater benefit from bilge-keels—other things being equal—than would a ship of finer under-water form, with a considerable area of nearly flat deadwood at the bow and stern. In no case, however, is it disadvantageous to fit bilge-keels; some gain in steadiness is certain to result from their employment.

When the naval architect has done his best to secure steadiness and good behaviour in a ship it still remains true—in fact may be regarded almost as a truism—that her behaviour will be considerably influenced by the dimensions of the waves encountered; or, to speak more exactly, by the ratio of her still-water-period to the *apparent period* of the waves, and by the steepness of the wave-slope. The reasons for this fact are easily discovered.

The cause of motion in the ship is the variation in the direction of the fluid pressure, due to the wave-motion; the *rate* of that variation depends upon the period of the wave, its *range* depends upon the effective slope of the wave. If a ship rolls passively broadside on to the waves their real period and their apparent period are identical: if she moves obliquely towards the advancing waves, their relative speed of approach is quickened, and their apparent period is less than the true period. On the contrary, if a ship moves obliquely away from the waves their apparent period is made greater than the true periods. Full directions as to the mode of estimating apparent periods of waves appear in the Admiralty circular on the subject; and, therefore, nothing need be added.

One of the simplest methods of illustrating the importance attaching to the ratio of the still-water period of oscillation to the apparent

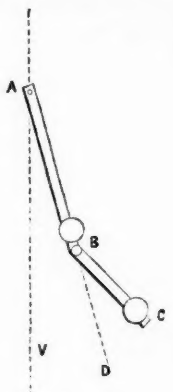


FIG. 4.

wave-period, is shown in Fig. 4. Let AB be a pendulum with a very heavy "bob," having a period for a single swing equal to the half (apparent) wave-period. To the lower end let a second pendulum be suspended, its weight being inconsiderable. Then, if AB is set in motion, its inertia will be so great that notwithstanding the suspension of BC, it will go on oscillating very nearly at a constant range, equal to the maximum slope of the wave, on each side of the vertical. A few critical cases may be chosen.

(1) Suppose BC to be very short and quick-moving when compared with the wave-pendulum AB. Then BC illustrates the case of a quick-moving ship on a wave of comparatively large period: and it will closely accompany AB in its motion, just as the little raft in Fig. 3 kept its deck parallel to the wave-slope. The types of war-ships coming nearest to these conditions are the Russian circular iron-clads, and the American monitors. On large waves such vessels would keep their decks approximately parallel to the wave-slope; and there is evidence that the "Miantonomoh" did so on her passage across the Atlantic. This quickness of motion, and accompaniment of the wave-slope (as already explained) may cause a considerable oscillation to take place, which may be imperceptible to those on board, but which would lessen the usefulness of the ships as gun-platforms. It is to be regretted that in the "Miantonomoh" only pendulum observations of rolling were made.

(2.) Suppose BC equal in length to AB. This is the case of synchronism, the half-period of wave being equal to the period of the ship for a single swing in still water. The ship-pendulum, BC, will then be found to perform very considerable oscillations, while AB is making very small oscillations; and the reason is obvious. BC receives a fresh impulse at the end of each swing, and therefore gradually acquires motion. The dangers of synchronism were clearly apprehended by some of the earlier writers, Bernoulli and Euler among the number; but the complete solution of the question was first given by Mr. Froude.

Many examples are on record of heavy rolling having resulted from synchronism or approximate synchronism. The singular behaviour of the "Dreadnought" previously mentioned was probably due to this cause. A similar occurrence took place during the towing trials of the "Greyhound, the "Volage" having rolled heavily in an almost glassy sea. One of the best examples that can be quoted, however, is that of the "Devastation." Lying passively broadside on to waves having a period of about 11 seconds, the ship was observed to swing through a total arc of 14 degrees. She was then steamed away from the waves at a speed of $7\frac{1}{2}$ knots, the wind and sea being on the quarter. The obliquity of her course to the line of wave advance was such that the apparent period of the waves became as nearly as possible the same as the period of the ship for a double swing in still-water—$13\frac{1}{2}$ seconds. Her arc of oscillation was then about doubled, being $27\frac{1}{2}$ degrees; 13 degrees to windward of the vertical, and $14\frac{1}{2}$ degrees to leeward. In this interesting trial the only condition varied was that of the ratio of periods for ship and waves; and it forms an unanswerable proof of the important influence which that ratio has upon the behaviour of ships.

In this connection it may be noted that the half-periods of large Atlantic storm waves such as Dr. Scoresby observed—600 feet in length and 10 or 11 seconds in period—very nearly synchronise with the period, for a single swing, of very many classes of war-ships. The converted ironclads of the "Prince Consort" class, unarmoured wooden frigates, and the larger classes of corvettes are included in this

category: and the superior behaviour of later ironclads in the Channel Squadron trials has resulted chiefly from their longer periods—7 to 9 seconds—which exceeds the half-period of nearly all the waves, having any great steepness, likely to be encountered.

The influence of change of course relatively to waves upon the rolling of a ship, is to a sailor almost a truism; it is explained simply by the change produced in the apparent periods of waves.

(3.) Suppose BC to considerably exceed AB in length; as AB oscillates, BC will remain almost upright. This illustrates the remarkable steadiness of ships like the "Inconstant" and "Sultan," amongst storm waves of ordinary size and common occurrence. Such waves might be from 200 to 400 feet in length, and have half-periods of from 3 to $4\frac{1}{2}$ seconds; while the still-water periods of the ships, for a single swing, would be 8 to 9 seconds. Following the language of our previous explanation it may be said that such ships move so slowly, as compared with the rate of variation in the direction of the resultant fluid pressure, that they can never have moved far before their motion is checked by the changed direction of that pressure. Hence large angles of oscillation cannot be accumulated. Waves which would synchronise with the ships would have extraordinary lengths—1,300 to 1,800 feet from hollow to hollow, or crest to crest. Waves of those dimensions have been noted it is true, but they are very rarely met with; and storms of exceptional severity are required for their production.

All these illustrations emphasize the importance of associating with observations of the behaviour of ships, simultaneous observations of the dimensions and periods of the waves, the course and speed of the ships relatively to the waves, and all other attendant circumstances likely to influence her motions.

The "experimental study of waves" has now become a necessity. It is astonishing to find on inquiry how small was our stock of exact information of the subject, before recent observations were made; and although much has been done of late, both in the French and in the Royal Navy, much still remains to be done. The task involves many difficulties, and considerable labour; but when it is seen what one observer may accomplish in a single commission, there can be no question but that the multiplication of intelligent observers would speedily add most valuable facts to our knowledge. Lieutenant Paris of the French Navy has published (*Revue Maritime*, vol. 31) an account of his observations on wind and sea, made during the cruises of the "Dupleix" and "Minerve" in 1867–70; this may be read with advantage by all who propose to follow in his track. His records are not perfect, nor free from doubtful features, but the general scheme of the observations was admirably conceived and executed. In the Admiralty circulars, full directions are given as to the methods of observing the dimensions of waves. Permit me, however, in conclusion, to enumerate the principal points to which the attention of observers may be advantageously directed.

(1.) The most valuable observations, from a scientific point of view, will be those made on a *single series of waves*, the successive waves

being not very dissimilar in form and dimensions. No doubt, in an actual sea-way, this condition of things is not often realised; the common case being that of a confused sea. But occasionally a single regular series of waves is encountered; and that is the time when the observations will furnish the best check upon the trochoidal theory of wave-motion, and the theory of rolling.

(2.) Observations on a *confused sea* should be made as detailed as possible in the particulars of dimensions and periods of individual waves. The method of *averages* cannot be applied here. Besides, we shall thus be likely to gain some better knowledge of the solitary large waves of which all sailors speak.

FIG. 5.

FIG. 6.

FIG. 7.

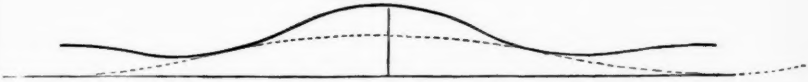


FIG. 8.

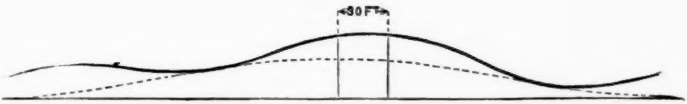


FIG. 9

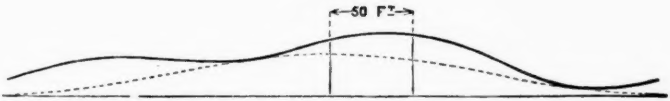


FIG. 10.

FIGS. 5—10.

A confused sea is formed by the super-position of independent series of waves, of different lengths, speeds, and heights, moving possibly in different directions. Hence arise almost endless variations in the surface configuration of the compound waves. As some of the simplest possible illustrations, Figs. 5 to 10 have been prepared. Fig. 5 shows the profile of a wave 400 feet long and 20 feet high; Fig. 6 that of a wave 200 feet long and 12 feet high. Suppose the two series of waves to be moving in the same direction, the larger waves under-running the smaller. Fig. 7 shows the compound wave when a crest of the 200 feet wave is directly over a crest of the 400 feet wave; $2\frac{1}{2}$ seconds later, owing to the greater speed of the longer waves, the shape of the compound wave will have changed to that in Fig. 8; after 4 seconds the condition of Fig. 9 will have been reached, and after 8 seconds that in Fig. 10. In such variations one finds ample explanation of the apparently contradictory records of wave-dimensions, made simultaneously by ships sailing in company, and also of the irregularity in form and slope of successive waves.

(3.) Especial care must be taken in observing wave-heights, for two reasons. One has already been mentioned, viz., the difficulty of determining the true vertical when a ship is rolling amongst waves, and the consequent danger of over-estimating the heights. The only trustworthy modes of measurement are horizon-observations, or anchorage of the measuring instrument to the practically undisturbed water below the wave. The second reason is, that observations alone can determine what will be the *limits of steepness* in ocean waves of different lengths; theory simply fixes the limiting ratio for a cycloidal, or breaking wave. So far as observations have yet been carried, it appears that the limiting ratio is never approached in deep sea waves: instead of being rather less than *one-third* the length in height, such waves are rarely *one-sixth* as high as they are long. Large waves, capable of considerably affecting ships, are said to have a ratio of height to length not exceeding 1 to 10, and the ratio falls to 1 to 20 or 1 to 30 in very large storm waves. Superposed waves, in a confused sea, may of course be steeper, but further facts are much needed.

(4.) It will be interesting to know what are the dimensions of the common or prevalent waves in various seas or oceans, as well as the sizes of the largest waves. Lieutenant Paris has tabulated his results for several regions, but I need not reproduce his figures, as they can be referred to.

(5.) The laws of wave-genesis have yet to be discovered; and they can only be deduced from a great number of observations of the force of wind which creates waves of certain sizes. Here a great field of inquiry lies almost unexplored. The French have shown us an example, it is true; and Admiral Coupvent Desbois has laid down a provisional theory based upon ten thousand observations. He supposes that the cube of the height of the wave is proportional to the square of the speed of the wind. There are objections to this provisional theory; but the attempt made is in the right direction, and I trust English observers may, at least, assist in the further progress of the inquiry.

We want to know what size of full-grown waves corresponds to a certain force of wind; how long the action of a wind must be continued to bring waves to their full dimensions; what are the stages of degradation in the wave-form after the wind ceases to act, and other particulars which will suggest themselves to any one interested in the subject. Care will have to be taken to guard against the improper association of winds and waves, observed simultaneously. Waves once created travel fast and far, maintaining their lengths and speeds possibly long after the wind which created them has ceased to act, and consequently the observed force of wind may not correspond to the observed wave-speed, length or height. This may account for a curious fact in the French records, viz., that the speeds of waves sometimes exceeded the simultaneous speeds of the wind. Measurements of the wind-speed made on board a ship in motion are necessarily difficult, and open to some doubt; but even approximate measurements will be of value.

Correct methods of observing the angles of oscillation of a ship at sea are now so commonly employed, that it is only necessary to remark that pendulums or spirit levels, or any other instruments depending for their action upon the directive force of gravity, are not trustworthy. Observations of the horizon furnish the simplest and best means of measuring the angles swept through; and the "batten instrument" is too well known to need description. The errors incidental to the use of pendulums or clinometers vitiate many of the earlier observations; cases being on record where the pendulum indicated *twice* the real angle of oscillation, but no such failures are likely to recur.

This hasty sketch of an important subject may, I trust, have the effect of awakening such an interest as may lead naval Officers and others to pursue the study for themselves. The main purpose of the paper has been to set forth the necessity which exists for further and more accurate observations of wave-motion in the deep sea, and its effects upon ships. It may well happen that, when the character of the information required by naval architects becomes more widely known in the Navy, no long time will elapse before such information is supplied; and, as a naval architect, I am grateful for the opportunity which this Institution has afforded me of making our wants known to its members.

Mr. Scott Russell, F.R.S.: I should be very sorry if we were to allow this interesting paper to pass without some marks of the interest which we must all have taken. There can be no doubt, that what we call the stability of a gun-platform is a very important element in all modern ships. Now, the instability of a gun-platform is due to two causes. It is due, first of all, to the instability of the element the ship floats upon, in other words, to the waves which are formed on the surface of the water; and next, it is due to the peculiar oscillations of the ship herself. It is suggested in the paper, I observe, very strongly, that what are called "bilge-keels," are a very important element in shipbuilding. Now, I think, they are a very important element in bad shipbuilding, but I do not think they are at all an important element in good shipbuilding. It strikes me that bilge keels are an abomination, and I will tell you why. The reader of this paper knows quite well, that getting a minimum extent of surface for a ship is a great element of the speed and other good qualities of the ship. What then do you do? You build a

bad ship, and then, to please my friend Mr. Froude, you cover it with projecting keels, in order to correct the faults which you commit in building the ship. I do not think that is an element in a good ship, therefore, if you please, I would throw these bilge-keels absolutely, not overboard, because they are there already, but I would endeavour to keep them out of the water and off the ship altogether. With regard to the subject with which the author concludes his paper, I quite agree with it, that the more the attention of sailors is directed to accurate observations as to the oscillations of their ships, and the oscillations of the waves, and the relations of the one to the other, the better. I also agree that those accurate observations are of great interest, but I would venture to add, that there is a subject of far greater interest than any of those observations on the badness of ships and their degrees of badness, and that far more important subject, to which I would call much more attention, is the original building of the ships, such, that whatever are the waves they meet with, long or short—for you and I cannot control the longness and the shortness of them—whatever the waves are that we meet with, we shall have on those waves the minimum of oscillation which is consistent with good qualities. I do not care two straws what the periods of the wave and the period of the ship are to one another, provided you have originally built a ship with the following qualities: that in smooth water it shall have the right degree of stability for carrying a proper quantity of sail, and that in rough water waves, whatever their period is, it shall have the proper moderation of degree of movement along with those waves. I think sea-going men have always called the one thing "stiffness," and the other "easiness." Now, the combination in the original ship of the right degree of stiffness with the right degree of easiness, that is the one thing which alone makes a good ship, in all velocities of oscillation of waves, and in all periods of oscillation of the ship herself. I am, therefore, merely urging upon you the great importance of doing as the author of the paper desires, making most careful observations as to the oscillations of your ships and of your waves. But I entreat you to remember, that at the very beginning of all these things, there is a far more important root, and that root is to make your ship so that she shall not roll much with the waves, that she shall not incline much in smooth water, that she shall never want bilge keels, or any of those most ingenious and clever devices for making a bad ship into a good one.

Mr. Reece: Might I just make one observation? Those gentlemen who have gone from Dover to Calais in the "Castalia," know that there is hardly any movement in the vessel. I should like to know whether the theory may be applied to the "Castalia," which, as I say, is a double vessel of extreme steadiness.

Mr. Greaves: If you will allow me, as a master in the merchant service, I should like to make a few remarks. Any man who has been at sea for any time at all, knows it is very rarely that we ever see for more than an hour or two, at any one time, the sea bearing the same superficial appearance; that generally speaking, the sea is mixed and confused. Not only do seas over-run one another and become super-imposed one upon another, creating a "smooth," which smooth will be a caution to any man who is a seaman to look out for danger afterwards, but we see one grand ground swell running in one direction, and in some mysterious way a pulse of the bosom of old ocean rolling up either at right angles or obliquely to it, and on both of these there will sometimes be witnessed the grand ocean storm wave. That is a position of the greatest difficulty to the ship master, because he may find that this motion of the ocean which is meeting his ship at an oblique line on his lee side, imposes upon him considerations in carrying sail, totally different to what he would be under, provided he had only to compete with the swell of the sea upon one side. He dare not carry sail, for if he did, this tremendous leverage coming up from the leeward would just simply snap his masts in two. Again, we very often find the ship becomes extremely uneasy, and why? Because she has too little canvas. Give her a couple of top-gallant sails and she becomes perfectly easy, that is to say, if the motions of the ship and the sea synchronize in such a way that they nullify one another. The first voyage I went to sea, in a ship out of Liverpool of 550 tons (A.D. 1835), a very fast ship, we carried out a large quantity of tile copper for the Bombay Mint, and also of rod iron and bar iron, the whole weight being stowed at the bottom of the ship. Above that was a mixed cargo,

while light goods were on the top. Before we got down to the line, on Easter Sunday morning at four o'clock, under the influence of a fiery trade and heavy following sea, the ship had such a fashion of rolling in herself, and had accumulated so much momentum in her roll, which was quick and jerky, that she flipped the three top-gallant sails right out, and there was only one thing to do, namely, look out for the first smooth, reduce the canvas, and then haul the ship by the wind. She was going $11\frac{1}{2}$ knots an hour, the motions had become perfectly frightful, as the ship was actually scooping the water with her top-gallant rail on either side, and flinging it with the jerk of the roll across the deck. Mr. Harrison, the first Captain of the Great Eastern, was our chief Officer. When that ship was hauled to the wind, the sail being reduced, the hatches were opened as soon as possible; the hold was broken into by a process of barrowing, the light goods were put upon deck, we then dug down until we got at the rod and bar iron, which we then built up in the middle of the ship so far as we could, and a quantity was brought up in the 'twixt deck, and the consequence was, as we got away before the wind again, she was a totally different creature, and in running down heavy seas off the Cape, and particularly with a sharp gale of wind off the coast of Madagascar, where the seas, after a sudden shift of wind, were running all ways together, she behaved as kindly as possible. That shows that it is the disposition of the weights of the ship that is the most important element, for every ship has a nature consequent upon her form, shape, or model. It is a great difficulty in modern ships at the present day to overcome this, because owners charter a ship to a charterer who has got the privilege of loading her by his own stevedore. I took a ship the other day in Liverpool to be loaded for the West Coast of South America. She was going to load one of the most miscellaneous and extraordinary cargoes ever put into a ship. I called the stevedore and asked him how long he had been at sea, his reply was "never." That "he did not know anything about it." I said to him, "It is like your "impudence then to undertake to load ships; you saw this ship in dock, did you "ever go into the hold? Did you ever look at her bottom?" Well, he said, "I "went betwixt decks." "Do you know what shape she is?" "No." "Then "how do you know how to stow her? This ship has the character of being the "greatest roller out of Liverpool, and I am going to take it out of her. This mixed "cargo gives you an immense advantage; build me a longitudinal stack of dead "weight in the ship, bring it up well in her midships, and then I guarantee that "she cannot roll." "I apprehend," he said, "what you mean." Now, it will depend altogether on what a man will do, because, unless he knows the internal shape of his ship, unless he has some general idea of her shape, he will not know what adjustment of weights to make. I will take you back to the time when I was a boy; when I read in one of Captain Chamier's "Narratives of a Naval Life," of one of our gun brigs, an old 6, or 8, or 10. A lieutenant was appointed to her who had the privilege of having things pretty much his own way; he was a very smart man, and the moment he was appointed he went into the dock and looked at the bottom of his little ship—his first command. Now, these ships had a notorious character, they were called "coffins," and all sorts of frightful names. He went down, studied the internal construction of the ship, he saw where all the dead weights had been placed; he looked at the position of every magazine, he studied the outside of the ship, and then went to the Superintendent of the Dockyard, and got him to allow him to make an entire alteration by the authority of the Admiralty, and to dispose of the weight in the vessel as he pleased. The consequence was his vessel was so fast, so handy, and so clever that he was detailed to do such duty as was never before performed by a vessel of the class, and which gave him the privilege of acquiring a reputation. In 1839, I joined the old "Java," of London, a teak ship of 1,200 tons, which had 10,000 copper bolts in her. She had been built in India, a ship that had a reputation so bad, that although she was forty-four years old, she was not allowed to do her regular turn—she had been, I must tell you, in the Honourable East India Company's service—simply because she used to be about six months coming home from India. During the voyage I was in her, Mr. McKirdy was appointed chief Officer, a gentlemen who had been brought up in Her Majesty's service. He went into the dock where the ship was lying, with a clean swept hold, and having well studied the formation of the ship, he decided to

have her trimmed sixteen inches by the head, whereas she had always before been supposed to be sailed about fifteen inches by the stern. He told the owners, Scott, Fairlie, and Company, that he was determined to have the ship loaded in that way. We made the passage out to Adelaide in ninety days, and an equally good passage home. We were at St. Helena with the "Belle Poule," French frigate, when she took away the remains of Napoleon Buonaparte, we sailed in the morning, she sailed in the evening, and she beat us, our port being London and hers Cherbourg, by two days. So much for being a practical man, and understanding that whatever ship you have, she is an experiment for you to dispose of her weight in such a way that she shall synchronize on her natural motions, so far as that is feasible with the motions of the sea, be kind and easy under canvas, not be obliged to carry more sail to keep her quiet than her stiffness will bear, and not oblige you to take more sail off her than you ought to take, simply because she is uneasy and unkind. A true seaman—a man who has harvested and garnered up experience at sea, and thus become practical, knows this as one of the fundamental questions in his profession—which is a life-long school, and to such a man the idea of artificially rolling a ship as an experiment is simply and broadly the last stage of a grotesque absurdity!

Captain Maclear, R.N.: I should like to say a few words on the method of taking observations at sea. I am quite sure that every one who has listened to this paper must be quite convinced of the necessity of careful observations at sea, but there is great difficulty in making them. I have tried in the Atlantic every day for a month together, sometimes three times a-day, to make observations of the waves, their height, velocity, and period, and I have found the greatest difficulty possible. I think every naval Officer here will agree that it is very seldom indeed, not one case in a hundred, that you find regular waves; they are always confused, there appear to be waves coming in two directions, or one set of waves overlapping the other, so that the greatest difficulty is experienced in finding out what you actually do observe when trying to note the true crests. In a month's careful observations I found the greatest difficulty, and I am quite sure there are many must have felt the same discouragement I felt, and been almost inclined to throw the whole thing up. I am sure we should be very much indebted to Mr. White, or any one else, who could throw light on this subject, so that we may know actually what to observe and how to record it. I can only say after great trouble that has been my greatest difficulty.

Mr. Scott Russell: Will Captain Maclear allow me to observe, that a gentleman who is quoted in the paper as having made beautiful observations upon the waves of the Atlantic—Captain Scoresby—made, at my request, a large number of observations upon Atlantic waves; he made them very successfully, and he made them chiefly in this way: he observed systematically the following things, and as I have observed waves at sea, and measured them in the same manner, and as I come, from my own observations on seagoing waves in the Bay of Biscay, where I made a large number of experiments, to what I have given as the law, or the relation of length of wave to its velocity, I may tell you how I did it. The manner in which I made the experiment was a very simple one. What I did was to take an opportunity when the ship's head was going as nearly as possible at right angles to a series of regular waves. I paid out a float, which float was appended to a very long line, on which I had visible marks showing the length of the waves; I then made a series of observations, showing how long each wave was from crest to crest, and how long each wave was in going from the mark on the crest to the mark on the crest. If you will simply put out a buoy and a long line with visible marks upon it, and if you will then note the velocity of the ship, you will very easily from this get the following results, viz., what is the length of each wave, and what is the time in which the crest of a wave goes from *this* to *that* point. In that way you get those elements which we desire to have, the period and length of the wave. The other observations are a matter of much greater difficulty, namely, observations of the period of oscillation of the ship itself. That is a very troublesome thing, and the author of the paper has very well explained what the very great difficulties are, because you cannot use the pendulum; but I think Piazzi Smith made a series of observations on his own yacht by a new method, in which he entirely got over that difficulty; and there was a famous French builder at Havre, M. Norman, who also

made a series of very beautiful little instruments by which he got over this difficulty altogether.

Mr. WHITE: This diagram, fig. 3, represents the surface method of observing, which I think is perfect in principle.

Mr. SCOTT RUSSELL: M. Norman's instruments get over a great many of these difficulties, and by that means a number of extremely accurate experiments have been made, but I think the whole matter brings us just to the point which the Secretary was good enough to call my attention to. In the mean time it is admitted that a series of accurate experiments upon the times, magnitude, and velocity of waves along with the periods of oscillation and extent of oscillation of the ships together, is very desirable and would be very useful. I think it might be a very important result of this discussion, if we suggested that a code of rules and suggestions, together with suitable instructions, should be issued by the Admiralty to Officers of ships, for the purpose of having carefully recorded those observations, which are, no doubt, very interesting and very important, and such a code of observations will enable Officers to do exactly that which is necessary for finding out with great precision, the information which might be wanted for reference. Although I do not see that the mere registration of these observations would enable us to build the wisest possible ships, yet, I think, that all the practical knowledge which you can get as to the results of the performance of ships ought to be put on record, and that some day or other good will come of it.

Captain MACLEAR: The difficulty I spoke of is not so much the method employed on board ships, but as to what you should observe in the waves themselves, of knowing what is the crest of a wave as Mr. White pointed out just now. If you are going at right angles to those seas on the drawings, figs. 5–10, it would, probably, puzzle you very much to know which is the trough and which is the crest of the wave, and I have in my notes, periods for waves passing the ship, varying very quickly from fourteen seconds to three seconds, which certainly must show I was mixing two series. I wanted to know whether anybody could show a good method of finding the crests of the waves.

Mr. SCOTT RUSSELL: On the separation of the different classes of simultaneous waves, I quite agree that that is a great difficulty, and the only way in which I have got over that difficulty is this: I have gone up as high as I conveniently could on the mast, and I have tried from above to separate the waves into these classes. I quite agree that is a great difficulty. I am sure nobody knows it better than the gallant Captain, and though I am not a Captain and not a sailor, yet, as I have gained all my knowledge of the sea from actual experience at sea, and in very heavy seas I can tell you, I have found that all the difficulties could be got over by the following methods, that is to say, by going to the top of the mast and first of all looking down and mapping the classes of waves. I have very often been in one of those confused seas, which I have been able, after sufficient study from the topmast-head, to classify into three sets of waves, and the three different directions which you know, after a change of wind, these three waves often have; I have been able to see what the relation of their times and periods was to one another, and then going back again, I have been able to put out three sets of lines of observation, and by careful analysis to separate the three classes of waves from one another. It is of great importance, before you begin an observation, to see how many classes of waves you have to deal with, and when you have, as I have seen, three classes of waves, it becomes very complicated, and it is only by a careful remembrance of the analysis that you are able to get over that extreme difficulty which lies in the very nature of waves.

Mr. G. BETHELL: May I just ask, with regard to the first part of the observations on the way of putting the float, attached to a line, overboard, whether great difficulty is not experienced in noting when the marks are on the crest of the waves, owing to the fact of the wave being a considerable distance from the observer. I have tried the same plan and have found very great difficulty in noting when the float or marks are on the crest of the wave, and have noticed that a considerable error in seconds can arise from this fact. I have also heard from other Officers who have taken a great deal of trouble about the matter, that this is a very great objection.

Mr. Scott Russell: I can only say that is a great difficulty, and it is only by long study and the little cleverness that sometimes grows out of long study that you can do it.

Mr. Greaves: I think the difficulty is what is generally called the "equation of "error" on the part of the observer. If six men are making an observation at the same time at Greenwich Observatory, you find that none of them agree; yet the difference between them is so infinitesimal, it only proves that each one has somewhat differed in the way of making the observation, although the observation may be perfectly correctly made.

Mr. W. John: I think, if I understood Mr. Scott Russell rightly, he said, "Design your ship so as to behave well among all kinds of waves," and with that I quite agree, provided it is possible. But circumstances have come to my mind in reference to two ships which were built on the same design, with which I had something to do a year or two ago. Of those ships one was for service on one part of our coast, and the other on quite a different part. They were sister ships in every respect, the lines were the same, the weights the same, and the result was that one behaved well and the other rolled abominably. Now that must have been due to the difference in the waves and the particular kind of sea which prevailed at the place at which the ship was moored. In view of that, I must say I quite agree with Mr. White in his observations as to the relation of the ship to the sea. You cannot make a ship which will not roll in any sea, and if you have a ship designed for service in particular waters it is of the utmost importance to know what kind of sea prevails in those waters. I do not mean to imply for a moment that the seas in those particular waters are always uniform, but there is a prevailing sea, and it is important in designing ships, especially ships for particular places, to have regard to particular waves, and to the particular sea with which you have to do. In reference to these two vessels, the rolling of one of them, as I said, was tremendous. I had observations taken on board, because I could not believe the reports that were made. Of one ship it was reported that she behaved very well, rolling moderately, but not much, while of the other ship the records by the pendulum were given as much as 45° in one direction. I went on board that ship on a moderately rough day for the purpose of giving some instruction in reference to the observations. I had as little faith as Mr. White has in the pendulum observations, and I arranged for a series of observations taken from the horizon, something similar to the Service observations, and to my astonishment, after two or three weeks' rough weather, when the reports came on shore, there was no question of the fact that that vessel had a roll of 45° in one direction. Again, the movements of the ship were very quick, but one peculiarity in reference to it which struck me was this, that the lee roll was as much as 45° or 46°, while the weather roll never exceeded more than 13° or 14°, and the difference was accounted for, as put to me, actually by the wind on the side of the ship. After making a calculation as to the possible effect of the wind on the side of the ship, I found it was impossible that, even in the heaviest storms on the coast, the force of the wind on the side of that ship would have heeled her more than 2° or 3°. What then was the reason for the difference between the 45° roll to the leeward and the 12° or 13° or 14° roll to windward? I should say these observations on the rolling of the ship were accompanied by observations on the size of the waves, as far as they could judge (they had not the means of measuring accurately the height or length of the waves in order to judge) of the length of the waves in regard to the length of the ship. The result was, as near as they could tell, there were waves about 100 feet long and 6, 10, or 12 feet high. I found the period of the wave was about half the period of the ship. Now, according to our own usually accepted theory, under those circumstances, the ship ought to have rolled towards the crest of the waves, because the period of the ship was longer than the period of the waves; but as a matter of fact—we put the results of these experiments on paper—I found the ship actually rolled away from the crest, just as if the period of the ship had been less than the period of the waves, and I must say that very considerably puzzled me, and to this moment I have not been able to account for it. I should say the only way in which I could account for the enormous roll to leeward and the small roll to windward, after eliminating the effect of the wind on the side, was that the ship was thrown over by one wave to leeward, and before she could recover herself

the next wave caught her and sent her down again, so that the ship was practically always rolling on her side. We have not yet been able to account for the fact that this ship rolled away from the crest of the waves although her period was double the period of the waves.

Mr. Greaves: Can you tell me the name of that ship?

Mr. John: I had rather not. The ship has caused some uneasiness, and we are endeavouring to cure her rolling. I do not think I should be justified in stating anything further.

Mr. White: I am exceedingly pleased that so many opinions have been elicited by the paper, and I am certainly inclined to believe that the opinions of all are in favour of the views expressed in the paper. Though that may seem a little contradictory, I will attempt to justify it. First, as to the "Castalia's" steadiness. I stated in the paper that a ship like the Russian circular ironclad or the American monitor, or any quick-moving ship, would not be likely to acquire any motion exceeding the motion of the waves. If you remember the little pendulum swung with the top pendulum,—the quick-moving ship kept her time nearly parallel to the wave-slope. If the ship, as the "Castalia" does on account of her great beam, stretches over a very large length of wave, then of course the average slope of that length is small, and any one who thought about the "Castalia" would expect her to be a steady ship on account of her quick motion and her great extent along the wave slope. So that the "Castalia" I shall put into the circular ironclad class, and expect her not to acquire any great oscillation.

With reference to the confused sea, I question whether any one has had the opportunity of studying more than I have done the observations made by other persons. I come to them with a perfectly impartial mind, and I must say sometimes I meet with results that stagger me, but I have always explained the matter by remembering what curious configurations the sea may attain on account of the super-position of the waves, and in the paper I frankly admitted that it is the very simplest case of super-position, and if you have a series of waves meeting one another obliquely or at right angles, you may get a state of sea that it is impossible to deal with scientifically, and I say for scientific purposes those observations are worth most which are made when the good luck of a regular series of waves is met with; and I quite admit that that is good luck, for on the few occasions when I have had the opportunity of observation I have come across confused sea rather than regular sea. Mr. Scott Russell may have developed the power of separating the different elements of distinct sea. I know if you went to the masthead, you would require one observer there to separate the sea, and another somewhere down on the deck to ascertain simultaneously the height and dimensions of the waves. But I do not think they are the conditions from which we can learn the most. I think in a difficult problem if you can make out the different elements of a problem, and consider each separately, you may by that means obtain the most information. Perhaps in time to come somebody may be able to deal with the most confused sea that ever was imagined, and to predict the behaviour of a ship on such a sea; but at present all I claim for theory is this: that, given a regular series of waves, and having given the results of still water experiments, you can predict with very close approximation what any number of such waves will do to the ship. That I think is a step ahead. Anybody who can contrast that kind of exact information with the helpless way in which in the old books on naval architecture—"And now we come to the case of " the behaviour of ships amongst seas, and we do not know anything about it,"—will I think acknowledge that we have taken a step ahead. I quite admit that canvas is of the greatest importance in steadying a ship, and in the observations made in the Navy the amount of sail spread is always noted carefully simultaneously with the observations. Stowage is a most important thing, and is mentioned in the paper as affecting the period, and I have here an apparatus to illustrate the important effect which stowage of weight has upon the period, but there was no time to show it. But all that leaves untouched these general principles; in fact, the statements made as to the behaviour of merchant ships just proves the point that I have been endeavouring to urge, that the longer the period of a ship the better her behaviour, because when these weights were low down there was a very stiff ship, a quick moving ship, and therefore an uneasy ship.

Mr. GREAVES: There was no reason why the ship should be uneasy, except the misplacement of weights.

Mr. WHITE: All these things are included in the period. The period of the ship is determined by her stiffness and the stowage of her weights. When I say the period of the ship affects her motion, I include in that, the stowage of her weights and her stiffness; so that all the facts which have been stated I claim in support of the view put forth in the paper, that the still-water-period of the ship is a most important element in her success at sea. As to the difficulty of making a series of observations, I should like it to be clearly understood, in reply to what Mr. Scott Russell has said, that for ten years or more in the Navy such a careful series of observations have been made. The series of observations as to waves is only just beginning, but the observations on the behaviour of ships and accurate means of making those observations have been known and applied for ten years past; and these instruments which Mr. Scott Russell has mentioned (some of which are beautifully designed and correct in principle, others of which are not correct in principle), have been also known. M. Norman has abandoned his instrument, but these instruments cannot compare in accuracy with the simple horizon observations which are the Service method. As to observations on waves, having read what the French have written on the subject, I know of nothing better than Mr. Froude's memorandum, which is contained in the Admiralty circular, and I can add nothing to that. Now, going to Mr. Scott Russell's objections, they are to my mind the most important comments that have been made on the paper, and I should like to make one or two remarks about them. Mr. Scott Russell says that you should make a ship which shall behave well amongst any waves. Now, as a matter of fact, we find waves that would affect large ships sensibly varying in their periods from something like 5 seconds up to 18 seconds, and I must say that to try to put every ship outside the effect of waves of 18 seconds period is, to say the least, a very bold endeavour. I do not think it has yet been done. More than that, I say that there are other conditions which come into a ship's design, more important sometimes than that connected with steadiness. Steadiness is obtained by long period, and in the body of the paper I referred to two classes. Take a central citadel ship. Can you make that ship steady by any choice of form? I think any one who looks into that problem will say that you cannot. To fulfil other and very important conditions in the design, you have to make the ship very broad, extremely stiff, when her ends are not riddled, and she will be comparatively quick with her movements. That ship will probably compare more closely with the "Prince Consort" class than with the "Sultan"—that is, apart from bilge-keels. Are we to throw away the proved advantage of bilge-keels for the sake of any supposition as to loss of speed?

Mr. SCOTT RUSSELL: Not supposition—certainty.

Mr. WHITE: I beg pardon. I used the word "supposition" with the fullest intention, and for this reason: if Mr. Scott Russell will consult Mr. Froude's experiments on the towing trials of the "Greyhound," he will find with that ship, fitted with bilge-keels 3½ feet deep, and a little slope, there was scarcely any loss of speed on account of the addition of the bilge-keels.

Mr. SCOTT RUSSELL: Was she high speed or low speed?

Mr. WHITE: An ordinary sloop.

Mr. SCOTT RUSSELL: In a slow speed there is, of course, very much less difference than in a high speed.

Mr. WHITE: I quite admit that apart from that experiment, if you adopt the law of frictional resistance, it follows the increased resistance when these bilge-keels are properly fitted is due to the surface friction, and I ask any one who has looked at the bottom of an ironclad with the deepest bilge-keels, what is the ratio of the surface of the bilge-keels to the whole surface of the bottom, and what can be the additional resistance proportionally of such bilge-keels? There are the two facts. Surface friction must be the addition. If they are properly put on, the "Grey-"hound" experiments show there is no perceptible loss of speed. The "Greyhound" trial proves this. She was tried against the "Perseus," and she accumulated one-half the angles of oscillation under identically similar circumstances, except that she had bilge-keels. Then take the case of the "Devastation"—a ship which necessarily had considerable stiffness, and necessarily had a shorter period than the "Sultan."

When at Berehaven she had bilge-keels added, and her bilge-keels made her as well-behaved to all intents and purposes as the "Devastation." Take the case of the "Faraday," the cable ship, a ship which from the very circumstances of her service could not be built for such sea-motions under all conditions. She had to carry the weights of that ship by means of deep bilge-keels, was made steady and very well-behaved, and they did all the operations in almost any weather. Are we, in view of such circumstances as these, and of the fact that in little ships you cannot get long periods, to throw away the advantages of bilge-keels? I have put, I think, as clearly as I can, in the paper the advantage of securing good behaviour by the conditions of the design so far as they can be fulfilled, but when you come to designs in which the conditions of steadiness cannot be fulfilled, then I think we do not sin against prudence in using bilge-keels.

The CHAIRMAN: It is my pleasing duty to ask you to give me leave to thank Mr. White most cordially for his lecture. I am sure we must all have admired the admirable and lucid way in which he has brought before us in a popular manner a subject which requires very high mathematical analysis. Not only has his paper all these merits, but he has elicited a very valuable and instructive discussion, and I think he has replied to the observations that have been made with very great ability.

Evening Meeting.

Wednesday, June 20th, 1877.

ADMIRAL OF THE FLEET SIR HENRY J. CODRINGTON, K.C.B., Vice-Patron, in the Chair.

COMBUSTION OF FUEL IN BOILERS.

By Captain HAMILTON GEARY, R.A., Instructor of Artillery, Royal Military Academy, Woolwich.

IT is not my intention this evening to enter into a discussion on the general question of the combustion of fuel for steam purposes—a question I am sure which needs no explanation on my part—but, with your kind permission, I hope to bring before you a *particular* method of treatment, which I have found experimentally successful, and which I have endeavoured to protect by a patent.

The subject naturally divides itself into two parts, first, the *fuel*, secondly, the *boiler;* each of them, I take it, of equal importance.

1. *The Fuel.*—I think it may be laid down as an axiom that *theoretically* the most advantageous fuel is that containing the largest percentage of carbon. But such is our want of ability or practical knowledge, that the richest fuel this country produces, rarely, if ever, finds its way into our coal-bunkers. I allude to the anthracite coal of South Wales.

A glance at the table on the wall will substantiate my statement.

Abstract of Average Compositions of British Coals.

Composition, per cent., exclusive of water.

	Carbon.	Hydrogen.	Nitrogen.	Sulphur.	Oxygen.	Ash.
A.	79·71	5·25	1·85	0·71	9·30	2·12
B.	76·04	4·75	1·80	0·64	9·75	2·58
C.	77·71	6·34	1·06	1·02	7·00	6·24
D.	90·60	2·96	0·77	0·32	1·92	3·44

The table represents the average composition taken of twenty specimens of British coals. Under A we have the average of five specimens of caking coals; under B of five of non-caking coals; under C of five of cannel coals; and under D of five of anthracite coals.

Perhaps some present may take exception to the deduction I make from a consideration of this table, that the coal under D has a far higher calorific power than the others by pointing to the much greater proportion of hydrogen contained under C, for example, and reminding me that the calorific power of hydrogen varies between 34 and 35 thousand. I think a little consideration will remove this, at first sight, natural objection.

In all fuel containing carbon, hydrogen, and oxygen, there is *invariably* sufficient hydrogen present to form water with the oxygen; in fact, it is *only* the hydrogen in *excess* which is available for heat-giving purposes.

Indeed, so eminent an authority as Dr. Percy considers that the hydrogen and oxygen contained in a fuel may be taken as water already, so that the carbon *alone* is the source of heat, and the carbon cannot be burned without the evaporation of this water, at the expense of the heat developed by its own combustion.

The hydrogen may and does undoubtedly assist materially in the generation of *flame*, but it is equally true that that portion which exists with the oxygen in the state of water, not only *does not* contribute to the *actual* amount of heat produced, but consumes no inconsiderable portion of it.

It is, therefore, evident that, could we so contrive boilers, or what is better still, adapt our existing boilers to burn this particular fuel with advantage, we should have made a great stride towards both efficiency and economy.

Anthracite, however, is subject to certain disadvantages when applied for steam-boiler purposes. In the first place, it is divided into two great classes, one of which "clinkers," and so requires a special arrangement of fire-bars. Again, the heat is intensely local, and with ordinary boilers does not flame. This is a manifest disadvantage with tubular boilers. The decrepitating variety of anthracite is the one most prevalent in the coal derived from the Welsh coal measures.

The practical disadvantages to the employment of anthracite, are the difficulty of utilising the slack, of which a large percentage is formed in the manipulation of the coal, and its tendency to split up into small fragments when suddenly heated. The resulting dust forms with the cinder, pasty masses, which cannot be burned away, and either choke the furnace or otherwise seriously upset its working.

These difficulties in the way of employing anthracite, have led from time to time to various attempts being made to derive from it a serviceable coke.

None of these have, as far as I am aware, been commercially successful, for although coke was certainly produced, it was friable, and generally of inferior quality.

Messrs. Penrose and Richards, of Swansea, in 1874, appear to have successfully solved this problem. It is not the time this evening to

enter into any detail of the process of manufacture adopted by them; it will suffice to point out that experience has fully justified the estimate I have ventured to make with regard to their coke; indeed, the comparative trials made at the Landore Works, some of which I have had the privilege of witnessing, and the manifest superiority of the anthracite coke to *all* others employed in the blast furnace, have led me to the consideration of the practicability of employing the same for steam-boiler purposes.

Table showing percentage Composition of Dry Coke.

A.		B.	
Carbon	89·58	Carbon	94·63
Hydrogen	0·44	Hydrogen	0·30
Oxygen and Nitrogen	1·92	Oxygen and Nitrogen	1·48
Sulphur	0·38	Sulphur	0·23
Ash	7·68	Ash	3·36
	100·00		100·00

A glance at the table will show that the anthracite coke under B has a higher calorific value that the coke under A, which represents the average composition of three different specimens of British coke. Again, the resulting ash is *one-half* in the case of the anthracite coke to that from other coke.

The specimens of this coke on the table have been taken from a heap exposed freely for the last eighteen months to the action of the atmosphere. It has suffered in *no* particular.

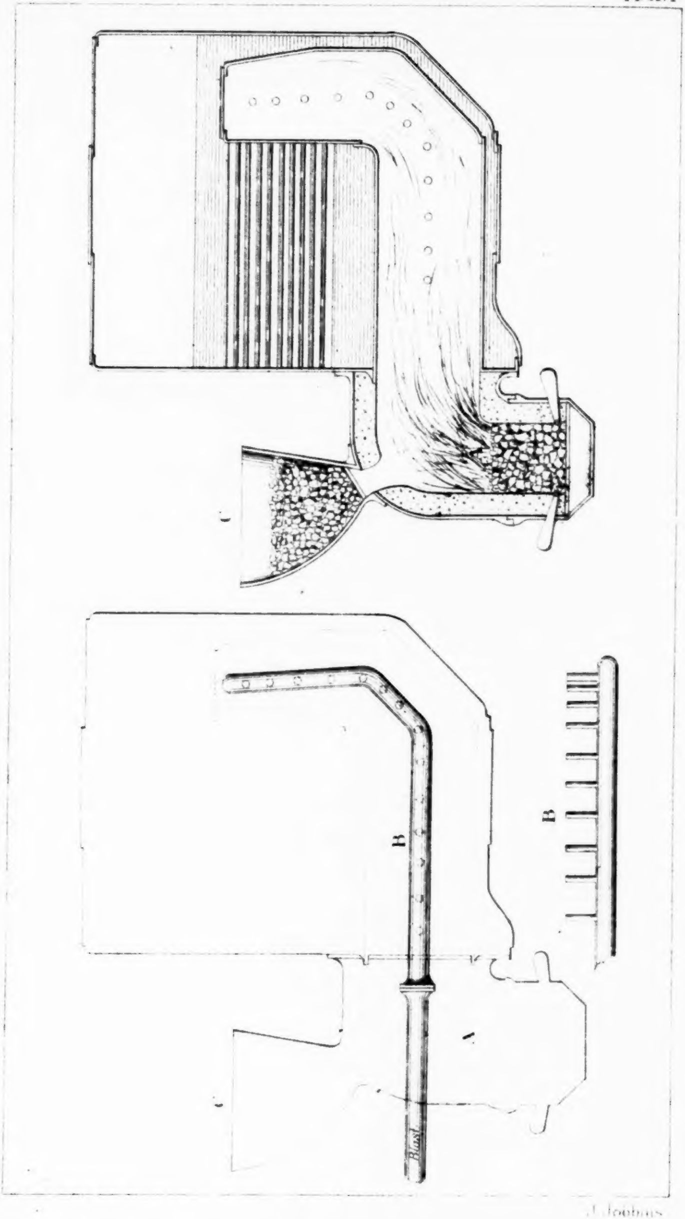
It still presents its characteristic steel-gray metallic appearance, nor did the pile from which it was taken show any sign of crumbling.

It may be as well to enumerate the advantages claimed for this fuel over other coke.

1. Higher calorific power.
2. Much greater hardness, indeed much harder than the anthracite itself.
3. In burning under blast or otherwise, with or without burden, it neither crumbles nor decrepitates.
4. It is about 23 per cent. heavier than the north country coke. Indeed, a vessel recently laden with 240 tons of the latter was able to take in 310 tons of anthracite coke.
5. Ordinary coke absorbs, when soaked, 10 per cent. and even more of water; anthracite coke between 1·5 and 2 per cent.
6. The low percentage of ash reduces the dust to a minimum, and the combustion of the fuel is unattended by any smoke.
7. The loss by crumbling is inappreciable.

These admirable qualities, as I have before stated, led me to consider the very great advantages which would accrue should it be possible to burn the anthracite coke in connection with steam boilers.

The problem to be solved consisted, 1st, in producing sufficient flame, 2nd, in burning the fuel with economy. The hardness and density of the fuel necessitates a high temperature to ignite it, and for this purpose a blast of air or steam must be employed.



J. Jobbins

By bringing the zone of combustion closer to the tuyères, there arises a diminution of the waste of fuel in the upper part of the furnace. But it would be as well to proceed to the consideration of the boiler and furnace itself.

As shown in the diagram, I separate the furnace from the boiler proper, in fact the furnace becomes a gas generator A. This generator is constructed much as an ordinary cupola furnace, closed at the interior part. The exterior is composed of iron rings or cylinders keyed together, and the joints stopped with fire-clay. The top is of a cowl shape, and fits tightly against the boiler face. The interior is lined with fire-brick or clay. As the anthracite coke produces but a small proportion of ash and that finely divided, it readily drops through the fire-bars into the ash-pit below. The blast keeps the fire-bars cool by striking above them. The diameter of the generator is the same, or nearly so, as that of the boiler tube, and I have found a depth of eighteen inches of fuel sufficient to produce the requisite reactions.

As is well known, the CO_2 formed at the interior part of the furnace in passing through the incandescent carbon is reduced to CO, and in that condition escapes from the surface of the burning mass. It now becomes a question how to supply the necessary oxygen for the combustion of this CO, and when supplied how to regulate the same, and produce a large heating surface for the boiler.

This is managed by means of the tube (B) passing outside the boiler, perforated with holes at stated intervals and of known diameter, into which hollow tubes are fixed, which, passing through the water, act as stays to the boiler itself, and open out into the main tube or flue of the same. Through this pipe air is driven.

It will be seen that the CO formed at the surface of the fire will have to seek for the necessary oxygen from the various orifices in the tube, in order to burn and be converted into CO_2; but as the supply of air is limited from each orifice, the unburnt CO will be induced to move forward to the next and so on, so that we can draw the hot flame of burning CO to any practicable distance.

I have found that the heat in the boiler is sufficiently high at the remote end to enable this to take place; and, moreover, this is assisted by the fact that the air which finds its way into the boiler tubes, is heated by having passed in close contact with the boiler, and the boiling water itself. This, of course, reduces the quality of heat consumed in raising the air injected.

Steam decomposed by heated carbon instead of air, would theoretically be preferable, as we should not have to waste so much heat in raising the temperature of the useless nitrogen, and we should have available the hydrogen, and there is nothing in the nature of the boiler and gas-producer I have described to prevent its employment; but hitherto I have been content with air, which has answered very well, and is more easily and readily available.

The tube arrangement for injecting air or steam into the flue of the boiler, admits of regulation in case of necessity, either by reducing the blast, or by closing one or other of the orifices.

As regards feeding the furnace. A hopper arrangement (C) with

sliding plates covering the entrance to the gas-producer, will enable one to charge the furnace mechanically, and entirely obviate the necessity of stokers.

The coke naturally splits up into long fingers presenting the appearance of the samples on the table, so that no labour need be expended in reducing the bulk of the pieces.

The chucks will fall vertically into the furnace, and a small peep-hole enables the fireman to regulate the depth of his fire. The smallness of the pieces of coke, allows a corresponding diminutive opening between the hopper and the furnace, and so diminishes the escape of the heat.

I have now described generally the nature of the construction of the boiler apparatus I prefer; a careful regulation of the blast will enable us to burn the fuel to a nicety as regards economy, the closing of the furnace economises heat, and keeps the stoke-hole cool, whilst the vertical method of charging obviates the expensive and distressing operation of stoking.

It will be necessary now for me to bring to your notice the results of the experiments I have been able to make.

Last year, having been satisfied as to the practicability of producing a large body of flame from the anthracite coke, sufficient in itself to produce a working head of steam in an ordinary locomotive boiler, this year at Neath, on 31st May, and 1st and 2nd June, the following more exhaustive experiments were carried out, and with these results :—

Trials of Coals and Patent Anthracite Coke.

May 31st, June 1st and 2nd, 1877.

Trial No. 1.—*Steam Coal.*

Fired under boiler at	11.0 a.m.
Steam gauge started from zero at	11.17 a.m.
Steam blowing off through safety-valve and steam gauge showing pressure of 32lbs., at	12.15 p.m.

Time taken to raise steam to 32lbs. = 58 minutes.
Weight of coal used, 2 cwt. 2 qrs. 25 lbs.
Specific gravity of coal, 1·320.

Trial No. 2.—*Anthracite Coal.*

Fired under boiler at	2.15 p.m.
Steam gauge started from zero at	2.26 p.m.
Steam blowing off and steam gauge showing pressure of 32lbs. at	3.18 p.m.

Time taken to raise steam to 32 lbs. = 52 minutes.
Weight of coal used, 2 cwt., 2 qrs., 12 lbs.
Specific gravity of coal, 1·370.

In both the above cases the quantity of cinder withdrawn was inappreciable.

Trial No. 3.—Patent Anthracite Coke.

Fired under boiler and blast turned on at .. .. 4.4 p.m.
Steam gauge started from zero at .. .. .. 4.13 p.m.
Steam blowing off and steam gauge showing pressure of
32lbs. at .. .. 4.45 p.m.
Time taken to raise steam to 32 lbs. = 32 minutes.

$$\left.\begin{array}{l}\text{Weight of coke used, .. 2 cwt. 1 qr. 4 lbs.}\\ \text{Weight taken out after trial, 1 cwt. 2 qrs. 7 lbs.}\end{array}\right\} = \text{2 qr. 25 lbs.}$$

Specific gravity of coke, 1·200.
Quantity of blast used = 953 c. ft. per minute.

Description of boiler in which trials were made:—

Shell, 20 ft. × 3 ft. diameter, with—
2 tubes, 20 ft. × 12 inches diameter.
Fire place 3′ 3″ long × 2′ 8″ wide.

From this experiment it follows that a boiler employed as I propose is superior as regards fuel consumed and the speed of producing a certain result, to a similar boiler fired under ordinary considerations in the proportion of 6·8 to 1.

For if A does in 32 minutes a work at an expenditure of 81 lbs. of fuel, and B to do the same work takes 58 minutes with an expenditure of 305 lbs. of fuel, we have the proportions—

$$A : B :: \frac{1}{32} : \frac{1}{58}$$

$$A : B :: \frac{1}{81} : \frac{1}{305}$$

$$\therefore A : B :: (58 \times 305) : (32 \times 81)$$

$$\therefore \frac{A}{B} = \frac{6{\cdot}8}{1}$$

These, I submit, are very important results. It is readily conceded that had a blast and gas generator been applied to the trial with steam coal the results would have been modified; but one of the chief objects of the experiment has been to show as much the superiority of the method of burning a fuel over that in common use, as the superiority of the fuel itself.

We must now consider, before being able to arrive at a definite conclusion as to the relative merits of this or that system, what is the *cost*.

The cost of anthracite coke at the ovens is about 15*s*. 6*d*. per ton.

Taking the average price of steam coal at the pit's mouth to be 10*s*., there is a balance in favour of the steam coal of 5*s*. 6*d*. per ton.

Taking weight for weight, as shown by the experiment quoted, *to do the same work, neglecting the time*, one ton of anthracite coke is equivalent to 3·768 tons of steam coal, and hence we have the relative cost as 1 to 2·34 for any specific work required.

So that, in point of fact, although anthracite coke is much more

expensive than steam coal, in its employment it is less than half the price.

There is the important question of relative bulk to be considered. A given weight of anthracite coke occupies a space, as compared with the same weight of steam coal, represented by the proportion 13 : 10, from which it is evident that the bulk occupied by anthracite coke in a vessel to send it a given voyage, when compared with the bulk of steam coal is 345 : 1000—

$$\text{Because } A : B :: 305 : 81$$
$$A : B :: 10 : 13$$
$$\text{Hence } A : B = 1{,}000 : 345\,;$$

or, in other words, the anthracite coke would occupy but one-third of the space required by the steam coal, leaving the remainder for freight, or in the case of ships of war for additional fuel.

I have now considered the chief features of the fuel and the boiler. Before recapitulating, it would be advisable to endeavour to meet and explain any difficulties which, I am sure, will have suggested themselves to many of my hearers.

1st. As to the practicability of producing the requisite blast, and then the loss of power thus entailed.

Most steam-ships possess a donkey engine. Such an engine, or indeed one of far inferior power, would be amply sufficient to supply the blast required. In the case of the experiment to which I have adverted, the pressure of the blast was 5 inches or $\frac{1}{4}$ lb., which I think is so small as to need no particular allowance to be made for it. This blast was sufficient to supply 953 cubic feet of air per minute to the furnace.

A stronger blast would produce more speedy results. When once a head of steam had been attained, a rod from the shafting of the engine itself would be sufficient to continue the blast, and liberate the donkey engine if necessary. Indeed, on an emergency the fire could be got up by a hand-blower.

2nd. Supposing the furnace to get out of order, how is it to be repaired at sea, for example? Most steamers have more than *one* boiler, and as there would be a furnace to each boiler, the vessel could proceed whilst the damaged furnace was being repaired.

Every vessel would carry some spare iron casings, and also fire-bricks, or such cylinders of fire-clay of the requisite size, as are made of Stourbridge clay every day to order. Should such cylinders be employed, a new furnace could be erected and in work in the space of three hours.

Moreover, there is nothing which could cause damage to the furnace, or render it unserviceable, except the burning away of the fire-clay.

The fuel *not* being in the presence of iron, as in a cupola furnace, the life of the clay is greatly prolonged. The roof of a reverberatory furnace in the Arsenal is found to last without repair for nine months, and therefore we may reasonably conclude that the furnaces of a sea-going steamship would not need repair so frequently. This

operation is inexpensive, as the cost of the fire-clay cylinders for a furnace with a radius of 12″, and depth of 36 inches, would be about *3l.*

As regards the filling of the hoppers (which would be covered to prevent the scattering of the fuel when there was a lurch), this could be arranged by a Jacob ladder from the coal bunkers direct, and so the lifting of the fuel by manual labour would be avoided. Indeed, were one to build a vessel expressly with a view to the employment of this particular boiler, the level of the coal bunkers could be so arranged as to obviate this necessity, for the top of the hopper need not be more than 4 feet 6 inches to 5 feet above the level of the engine floor. Again, as regards the complication of the waste-pipe arrangement by which the flame is drawn through the boiler-tubes, though I consider it to be a decided advantage, as regards the efficient burning of this or other fuel, the boiler would work favourably if an excess of air were blown in at the tuyères, sufficient to supply the necessary oxygen for the combustion of the CO.

The short tubes or stays communicating with the boiler-tube tend to strengthen the boiler itself.

3rd. As to the supply of the fuel, anthracite has been but little employed in this country as compared with other coals.

For malting, and for a little copper smelting, it has been used for some time, but it is only lately that attempts have been made on any scale to take advantage of its high calorific power, and of its comparative purity, to use it in steam boilers. Even then a considerable proportion of other coal has to be employed, which detracts greatly from the results obtained from the use of the anthracite.

We may therefore consider our vast anthracitic basin at our disposal *intact;* and its employment in the form before us will give us the maximum of its valuable properties with a minimum of waste, for the slack of anthracite is *admirably* adapted for the manufacture of anthracite coke.

It only remains for me briefly to recapitulate the advantages claimed by the use of a particular and readily procurable fuel, and then when burnt in a particular way, as compared with the method of fuel in common use.

I. To do a given work there is a saving of between three and four times the fuel by weight.

II. There is a saving of two-thirds the bulk and consequent gain of freight.

III. The cost for the fuel alone is less than one-half.

IV. There is no appreciable loss by weathering, or by disintegration.

V. Stoking, as at present carried on, is obviated.

VI. The fuel is more completely consumed.

VII. The fuel is not liable to spontaneous combustion.

VIII. It absorbs one-fifth the amount of moisture.

IX. On account of its purity the boiler is not burned.

X. There is an absence of dust and smoke.

XI. The engine-room is both cool and clean.

The advantages which would be derived by a fleet from a successful application of some such method can hardly be exaggerated. Its strength would be more than doubled. Apart from the question of cost, a war vessel would be able to treble its voyage without calling at a coaling station; the number of coaling stations could be reduced, and a large store of fuel could be kept in any climate without fear of deterioration. The flame and smoke from the funnel, which render a war steamer a target by night, and the discoverer of its own track by day, would be no longer found.

In conclusion, I beg leave most earnestly and emphatically to disclaim any idea of having made any startling discovery; my sole object in coming here this evening is to lay before you the results of experiments and experiences which have occupied my attention to a great extent for the last few years, in the hope that I may have assisted, in however humble a degree, in helping forward one of the great questions of the day, and one which so urgently calls for a satisfactory and speedy solution.

The CHAIRMAN: There are one or two points upon which I should like some further information, and first I should like to ask whether that fuel is strong enough for shore use, for instance, in iron foundries for the purpose of smelting iron?

Captain GEARY: I have seen it in use at the Landore Steel Works; they prefer it to any other known fuel, and they use nothing else. It will stand practically any burden.

The CHAIRMAN: With regard to its use on board ship, I do not know whether, considering that our space is so restricted, you contemplate putting it up in that particular shape?

Captain GEARY: Certainly, as far as the generator is concerned.

The CHAIRMAN: It is very much a shipbuilding question as to how the system can be adopted in the smallest possible space, because our ships are so restricted for space; and results which may be excellent on shore may be sometimes difficult to obtain on board ship, owing to the restricted space.

Captain GEARY: I tried that experiment, and found that with 18 inches of fuel the height of the cupola would not be more than 3 feet. I asked a marine engineer whether they could give us 4 feet in height in an average ship above the engine floor, and he said they could spare 4 feet. In some of the smaller steamers, such as the river steamers, I dare say you could not adopt it.

Mr. SCOTT RUSSELL, F.R.S.: I think it must be to all people practically acquainted with steam navigation, a very important piece of good news that some means are now being adopted to utilise the enormous store of excellent anthracite known to be buried in Wales, which hitherto we have made so little use of. It has long been well known to us in this country that the Americans use their store of anthracite to a much greater extent than we do, and I have always heard that the great virtue of anthracite is, first of all, that it is a sort of natural coke ready made to hand; and, secondly, that it is coke extremely well purified of the disagreeable contents, such as sulphur, which a great many ordinary fuels contain a great deal of. Also the proportion of ash in it is extremely small. And therefore we welcome the announcement of the writer that he sees his way, and has decided it by experiment, to using our English store of anthracite in the manner which he finds convenient, manageable, and profitable. Of course, we can see at once that a fuel which generates a good volume of gas, a large proportion of which may not be good for combustion, wastes the whole of the heat which is employed in generating that gas, which is sent up the chimney without doing any good, and therefore when he brings us this extremely dense fuel, which contains so little except the substance we want, namely, carbon: and when he feeds this 94 or 95 per cent. of pure carbon with a quantity of oxygen direct from the air, then at once it is quite plain that he is effect-

ing combustion in the most economical way. But the economy which he produces is perhaps still more indirect for steam navigation than direct, because if he, by using a pure carbonaceous fuel, escapes altogether the burden of weight of useless matter which is in common fuel, and economises also the space for fuel which this useless matter filled, there is another source of economy. He has not divided to us the different sources of economy, which appear to me to be three. One is, not putting useless matter into the fuel, so as to occupy a part of the hold of the ship; the second is not employing any heated volatilising matter; and the third is getting us the best possible fuel. His mode of burning the fuel may be open to some objections, but it is consistent with all we have heard of the difficulty experienced in America of burning anthracite: that it is quite necessary for burning anthracite properly, that it should be burnt under a blast, therefore Captain Geary very properly burns his fuel under a blast. In regard to his mode of burning it, I dare say he knows that there are some other people who have had experience in these methods of burning, and I dare say he has availed himself of their knowledge in regard to the mode of introducing air through the boiler by tubes which serve as sides. I dare say he knows very well that that is the method adopted by Mr. Beattie, and in regard to the method of using fuel in the blast, I am quite sure he does not claim any originality in that. But that he is there, under the blast surrounding the fuel with brick, doing his combustion in a wise way, is I think unquestionable. All the other matters he will find out perhaps by-and-bye. There are a great many difficulties and inconveniences, as he himself has properly said, in introducing combustion under blast into steam navigation. I can easily see many disadvantages and inconveniences which, especially at first, would result from that; but of course that results from every new improvement, and of course there is experience to gain, and there are difficulties to be overcome. I for my part recognise the great advantage to steam navigation in combustion under pressure by blast, instead of by open funnels, and I have no doubt when we have made other improvements with reference to steam navigation, burning a pure fuel like this will be found of far greater value than burning any ordinary fuel, and that burning the fuel in our boilers under pressure by artificial blasts will be found by-and-bye to have a great many advantages over combustion by open furnaces and an open funnel.

Mr. Donaldson: May I ask the lecturer if the results he has given us as to the value of this fuel are results derived from extended experiment, or are only deduced from the time taken in getting up steam in the experiments he has described.

With regard to the use of a separate furnace, I should like to ask if the lecturer finds this necessary on account of any difficulty in burning the fuel in the ordinary way. We find no difficulty in burning Welsh coal under pressure (sometimes as high as eight inches of water) in the furnaces of the locomotive boilers of the steam torpedo launches built by my firm, and I think it would simplify the lecturer's apparatus if he could succeed in burning his fuel in a somewhat similar way.

I fear there would be some difficulty in arranging the blast-pipes in the way proposed by the lecturer in a marine boiler, especially where there were several furnaces in a row; but possibly he may have been able to overcome the difficulties, and can tell us what has actually been done.

General Campbell, R.A.: I have had some experience with anthracite in the Arsenal at Woolwich, where I was the means of introducing it, and I found that where there was a good draught there was no difficulty at all in burning it. It required to be set going with a little common coal, but when there was a good draught there was no difficulty in burning it pure and simple after once lighted. In other parts of the department I found that it would not burn well; it was obliged to be mixed; and in other places where there was no blast at all they could not use it, but with a good blast it burnt as well as possible. I do not mean an artificial blast, but when the furnace was well exposed, and had plenty of air, it was very much cheaper; and one great advantage was that there was no smoke. With regard to the arrangement there, I see a difficulty on board ship; but I do not see any difficulty in applying it to land furnaces. It will no doubt be a saving in expense and give a far superior effect.

Mr. Flannery: There is one point of difficulty which occurs to my mind, though it may be capable of explanation. The question I wish to ask is whether this system

of burning anthracite will give the same amount of power in a boiler that is obtained with ordinary steam coal? I understand the difficulty in burning anthracite up to the present time to have been this—first, that the amount of steam which is developed from anthracite is not nearly so great for a given time as that developed from steam coal. Some experiments made at Portsmouth Dockyard showed that 20 per cent. less weight of water was evaporated per hour. I wish, therefore, to ask if by this system a boiler will develop the same amount of horse-power with anthracite, as it would in burning steam coal. Is was my good fortune some two months ago to attend some experiments, extending over about a fortnight, in South Wales, on the burning of anthracite. It was not burnt in the form of coke, but in its natural form as it came from the mine. The system was by hollow fire-bars, which had holes at their sides, arranged much in the same way as ordinary fire-bars, and it was found that one of the great difficulties which had hitherto attended the burning of anthracite coal was entirely avoided; that is, that the bars usually became hot, and have been known to fall into the ash-pit. The effect of the blast going through the centres of the bars kept them perfectly cool, and after experiments extending for five hours the tops of the bars were found to be quite black. I am not in a position to give the exact figures of the result, but we found the economy to be greater than that of the best steam coal, and the power of the boiler under blast to be about 33 per cent. more, that is, 33 per cent. more was brought out in weight of water evaporated. I do not think it is necessary to tell gentlemen here what an enormous advantage that would be to a steam-ship, because when you have to put boilers of a given power into a steamer, if you can obtain 33 per cent. more for the same cubical capacity of the boiler, you of course very much lessen the weight and space occupied by the whole machinery. With regard to the practical difficulty which has been suggested of Captain Geary's arrangement, I cannot see, in my own humble opinion, that there are any practical difficulties in arranging such a furnace in the stoke-hole of an ordinary ship. Assuming the width across the combustion chamber 2 feet, which is about the usual distance, then we find that the distance from the ship furnace proper to the bottom of the bars which contain the coke is something like 2 feet 6 inches. In most boilers fitted in ironclads the boiler is quite 2 feet 6 inches above the level of the floor of the ship; therefore, you have only to move the stoke-hole floor in order to have a distance quite corresponding to what the author has shown, some 4 feet 6 inches or 5 feet. We all know there is about 6 feet headroom in a stoke-hole. Of course there is some difficulty in opening the smoke-bar doors in such an arrangement. Then about the objection Mr. Donaldson has urged. Of course there would be extreme difficulty in getting horizontal bars in the middle furnace, but I doubt if there would be any serious difficulty in getting them into the outer furnaces. As far as I am able to judge, and I have studied the use of anthracite a little, this is an extremely promising invention. I should like to have the point settled as to whether the boiler is really giving off the same amount of steam with anthracite coal burnt on this system as it would with burning ordinary steam coal.

Captain Colomb, R.M.A.: I cannot help drawing attention to the immense importance, in an indirect sense, of the question brought forward by the lecturer. Mr. Scott Russell has alluded to one of the direct advantages to be gained, and I should merely wish to allude to another, that is, that the distribution of anthracite is very favourable as regards our own possessions. Take the district of British Columbia, Vancouver's, and many islands, so far as we have been able to hold surveys, there has been the presence of this anthracite, which we can make no use of whatever. And I am sure it is quite unnecessary for me to point out the enormous advantage that would be given to our fleets if it was practicable to adapt our system of furnace-boilers to its use, because it would simplify a very important question, that is, the provision of coals not only for our fleets but for our mercantile navy in time of war. Another very important question is that by the use of anthracite, the same bulk would carry our ships very much further than with the use of steam coal; and that is a very important point when you remember the enormous extent of our lines, and that (as I mentioned the other day) we have no coal between here and Sydney. I rose to remark upon those two points, first, that it is incumbent upon us to do what we can to develop the sources of anthracite for the use of our ships; and, secondly,

that it is a question which has a very great bearing upon the coal-carrying of our ships, as was mentioned by Mr. Scott Russell the other day.

Captain GEARY: Mr. Donaldson has asked me a question, whether the results which I have quoted are those of one or of a series of experiments. I made a series of experiments last year, without taking any particular data regarding them. I wanted to satisfy myself, first of all, if I could obtain a flame from that particular fuel, and then be able to conduct it through any length that I might require. When I satisfied myself upon that point, I tried it in an open furnace, stoking in the ordinary way, merely taking the precaution of applying the blast above the firebars, and obtained certain results. But those results were certainly 40 per cent. inferior to those resulting from the method of removing the fuel entirely from the boiler, and closing it in, as seen in the diagram. The reason for not adopting the ordinary method would be, first of all, stoking, which I consider of very great importance; and then, secondly, the great loss of heat. Anybody who has been across the channel, and watched the stokers every minute opening the fire-door and shovelling in coals, will appreciate this. Then, as to the mechanical difficulty Mr. Donaldson raised about the arrangement of the tubes for the blast, I frankly confess I am not able to answer him; it is more of an engineer's question, and I could not possibly say, without long consideration, what particular method would be best adapted for a whole row of boilers. It is a point which I should leave to engineers to solve; I could not possibly say without going thoroughly into the question of known engine-room with known boilers of a certain capacity. General Campbell has alluded to the fact of having burnt anthracite at Woolwich Arsenal. I have seen that myself, but I think there would be some difficulty on board ship, because I think the gallant General said that there was a difficulty in burning anthracite where he had not got sufficient draught. I think that the question of sufficient draught might, to a certain extent, be found on board ship. You would not have that free access of air which you would have in an open place, like the Arsenal; at all events, you would materially facilitate it by applying the artificial blast. Mr. Flannery has asked whether anthracite will develop the same steam power over the same area as steam coal will. I think the result of these experiments shows that it certainly does. The experiments were tried with precisely the same boiler under the same conditions; a certain head of steam was got up in nearly half the time that the other was, and an expenditure of one-fourth the amount of fuel as running through the whole. I think there has been a confusion between anthracite coal proper and anthracite coke. One of the chief features I wished to draw attention to this evening has been anthracite coke. In the experiments quoted, I have tried the system with the anthracite coal, and the anthracite coal was certainly better than the ordinary steam coal, but it is 50 per cent. worse than the coke. Only the day before yesterday I passed a cargo of 100 tons of anthracite coal, and certainly 15 per cent. of that was in a state of fine dust, caused by passing it from the ship-board to the side. Therefore, when you come to take anthracite coal to Malta or Gibraltar, each decantation of that coal will reduce the stuff you will eventually have to burn; whereas, I will guarantee to take a shipload of the coke to China and discharge it, and bring it back again, and not lose 3 per cent. This is a matter of observation and calculation. Then, again, in the question of anthracite coal, some gentlemen may have lost sight of the fact of the evil of decrepitation. The Welsh variety is essentially a decrepitating variety and necessitates special arrangement to prevent the whole of the gas generator being stopped up, apart from any other considerations. Whereas there is no decrepitation or crumbling when the coke is heated, and the amount of ash is infinitely less, so that I shall conclude by asking you to make a vast distinction between coke derived from anthracite and the anthracite itself, because, as far as speed is concerned, it is the difference between the race-horse and the cart-horse.

Mr. SCOTT RUSSELL: Would you explain to us what you mean by anthracite coke? for I do not in the least understand what anthracite coke means; anthracite being already purified of most of its gases, and so on.

Captain GEARY: The term "anthracite coke" is the one adopted by the patentees, and I use it as the word which they themselves have chosen to adopt. I know there have been several attempts made to convert the slack of anthracite coal into coke. There have been attempts by mixing it with pitch and bituminous coal, but hitherto

there has not been a commercial success. In the present instance, whether by the proportions they mix it in, or whatever it may be, the patentees have succeeded in producing a sound coke. This particular fuel is made by means of coating the surface of the anthracite slack, which has already been mixed with pitch, with a certain thickness of bituminous coal, the idea being to protect the pitch from burning away. Previous patents have neglected this outer covering of bituminous coal, and the consequence has been the pitch has all burnt away before the coking has taken place, and there has been an enormous wasting of fuel, so much so that, putting in, say, 100 tons of the amalgamated materials, they have been only able to produce 50 tons of coke; whereas, by coating it with this outer stratum of bituminous coal, they have been able to get as much as 85 per cent. of result in coke.

The CHAIRMAN: It appears that the subject which has been brought before us by Captain Geary is one of immense importance. Assuming always that we can get this material as a fuel in sufficient quantity for use and of unvarying quality, it really is of the greatest importance. There is something I might ask for, which I hope we shall see by-and-bye, but it is not quite in Captain Geary's department. We have a certain number of ships already fitted for the burning of the ordinary sort of fuel; it would be expensive to alter these entirely for burning this fuel, but it is very desirable that we should be able to burn this in all our ships, if we can get the fuel in the quantity which I hope, from what Captain Geary says, we shall have. It is also necessary that our furnaces should be able to burn both sorts hereafter, because we might find sometimes one coal in one place and another in another. I should say it is not at all beyond the power of the inventive genius of the present day to adapt furnaces to burn either one sort or the other. We have already the means of burning both light fuel and heavy fuel in the same ships. They require very different stoking and care, and I have not the least doubt we shall be able, with very little care, to adapt our furnaces to burn this anthracite coke. I hope we shall, for it will be an immense improvement if we can get fuel of this kind. It will, as the lecturer says, increase the power of our ships in every way, both as to locomotion and as to the durability of their service in war; for we must always remember that the efficiency of a ship really and truly depends upon the efficiency of its motive power in action, and this would give much more of that than any other coal that we know of. I think you will join with me in thanking Captain Geary for his very instructive lecture.

LECTURE.

Friday, July 6th, 1877.

ADMIRAL OF THE FLEET SIR HENRY J. CODRINGTON, K.C.B., Vice-Patron, in the Chair.

ON AN IMPROVED WAR-ROCKET FOR USE IN BOTH MILITARY AND NAVAL OPERATIONS.

By Commander JOSHUA COLE, R.N.

THE paper which I have the honour of reading before you this afternoon owes its origin to some remarks made on the 11th May, during the discussion following a very interesting lecture delivered by Mr. Donaldson on the subject of Messrs. Thornycroft's Steam Torpedo Launches.

On that occasion a discussion took place as to the best means of arming these vessels for attack and defence, and the merits and demerits of the torpedoes in present use were dealt with, the attention of those present being drawn by Captain R. A. E. Scott, R.N., to their dangerous character (notably that of the Whitehead) whilst still in the hands of those operating with them. He further expressed his opinion that we possessed in the Hale war-rocket a weapon, which, if intelligently improved upon, might be rendered more destructive than any torpedo, and his regrets that owing to the death of the late lamented Mr. Hale the invention only remained to us in its crude form, and that no further development had been made in an evidently valuable weapon.

Seeing that no member present on that occasion seemed to be aware that a very radical change has recently been made in the construction of these projectiles, and as the improvements introduced by Mr. John Macdonald, with the specific view to torpedo-warfare, have materially increased its capabilities of range and destructiveness, rendering it at the present time a projectile supplying all the wants of the artillerist, I am induced to draw up this short paper, in which I shall endeavour to explain what the alterations are, and the advantages derived therefrom, describe the construction of the torpedo-rocket for land service, give a short notice of a sub-aqueous rocket, or rocket-torpedo, and the proposed means of firing it, pointing out the advantages it possesses over present forms of torpedoes, and to invite discussion thereon, in order, if possible, to advance the science of torpedo attack and defence one step nearer to perfection, and to place the use of rockets in a more favourable light than it has hitherto held.

Mr. Hale, who fully endorsed the statement of Sir W. Congreave, that the rocket is "the soul of artillery without the body," evidently

never intended that his invention should remain for ever in the imperfect form in which it is at the present moment used by both services, but aimed at the eventual supercession of the gun by the rocket, the abolition of expensive ordnance, difficult of transport, and the retention simply of the easily portable, durable, death-dealing projectile. The recent alterations certainly have not fulfilled the patentee's aspirations in their entirety, but in one respect, they have probably done more than he ever anticipated, for their author maintains that we are hereby supplied with an efficient torpedo, which excels all others in cheapness, facility of manipulation, safety in the hands of the operators, long range, and destructiveness, whilst the smaller sizes afford us an effective means of defence against attack by the outrigger torpedo.

In order more clearly to explain the alterations made, and benefits obtained from Mr. Macdonald's invention, it will be necessary that I should state briefly the construction of the old Hale war-rocket, which is manufactured in several sizes, viz., 3, 6, 9, 12, and 24-prs., of which, however, only the 9 and 24-prs. are in use in the services, and these may be said to have reached their fifth edition, owing to alterations which have been introduced, with a view to improving their action or preserving them in a serviceable state. The case is made of Atlas metal, tubular in form, soldered together, and is driven with composition (ground saltpetre 70, sulphur sublimed 16, ground alder charcoal 23 parts), in the centre of which is a conical air space to enable a larger surface to be ignited at once, and thereby a greater amount of gas to be generated. To one end is riveted the shot, of cast-iron, conoidal in form, whilst the rear of the tube is closed with a disc perforated for the escape of the gas, and which has a prolongation formed of radiating segments of circles, which may be described as conical vents cut away on one side, the pressure of the escaping and expanding gas against the concave sides of which imparts the rotatory motion to the rocket; the propelling force being due to the pressure of this same gas against the atmosphere and the difference of the inside pressures on the head and base of the rocket.

The performances of the old Hale war-rocket may, I think, be fairly summed up in the following table, compiled from the Ordnance Select Committee Reports:—

24-pr., weight 25·746 lbs., length 20·8 inches, diameter 3·7 inches—original pattern.

24-pr., weight 26,139 lbs., length cylinder 18·1, tail piece 1·281 inch, diameter 3·76 inches.

	Elevation.	Time of Flight.	Mean range. Yards.	Mean deviation. Yards.	
		"			
May, 1865.	2°	..	187	1·3	
	5°	3·65	875	19·5	Rockets steady.
	10°	9·31	2,155	59·6	Ricochetted straight.
	15°	14·22	3,272	123·9	
	20°	16·18	2,818	139·5	
	26°	21·75	4,476	205·0	

At 2,306 yards mean range, the mean variation in range was 181 yards and the average deflection 62 yards. Now this must be considered as anything but satisfactory; the great deflection at the higher ranges would not matter so much were it a constant quantity, but, unfortunately, it is variable, and as no two rockets give the same result, cannot be allowed for; the mean difference in the range is also very great. Both these defects in the old Hale war-rocket are attributable to the wobbling of the projectile at the time of its quitting the trough or tube from which it is fired, and which is observable on all occasions in a greater or less degree. This wobbling is caused by the rocket being rotated at one end only, the head being the heaviest part takes larger circles than the tail until the rocket has got up its perfect rotation, which is not until it has passed one-third of its flight. In other words, the Hale rocket is not sufficiently rotated at the moment of firing, and until rotation is perfect, it is subject to influences which vary according to the circumstances under which it is fired.

The great deflection in the Hale may also be attributed to its comparative small initial velocity. That the inventor was sensible that his rocket might be improved in this respect, appears from a work written by him, and published by Mitchell, of Charing Cross, in which he compares his rocket with a rifled projectile, in which he says:—" It may be said that rockets invented by me have been made " to rotate without ensuring uniformity of direction or range as a " consequent result of rotation; yet, admitting this, it may be con- " tended that the rotation has not been sufficient, nor the manner of " effecting it such as to produce the best result." And afterwards, when comparing the performances of the rotary with the stick rocket, he proceeds:—" It is not, therefore, unfair to assume that the rotation " of the rocket being the only assumable cause of the improvements " effected, were the quantity of rotation duly proportioned to the " rectilinear velocity and the rotation applied in a more efficient " manner, a perfectly correct line of flight would be obtained."

In considering these remarks, it presented itself to the mind of the patentee of the "Improved Hale-Macdonald war-rocket," that if greater initial velocity and increased rotation could at the same time be obtained, the accuracy of flight in the rocket might be more assimilated to that of a rifle projectile, and the question was, how was this to be obtained? By reducing the diameter of the escape-holes in the base, the range would probably be increased, but the velocity of the rocket would have remained the same, as what would be gained in the increased difference between the inside pressures on the head and base of the cylinder, would be lost in the diminished area of the atmosphere acted upon by the escaping and expanding gas, the angle of expansion of which would remain the same; but by this means the rotatory motion would be diminished, and the accuracy in flight consequently impaired, the rotation not being duly proportioned to the rectilinear velocity.

A means, however, presented itself, whereby increased rotation and

velocity might be obtained, and possibly the required proportions maintained between the two, namely, by giving to the head of the rocket a series of gas escapes and flanges similar to those in the tail, whereby the rotation would be increased, and as this would involve the hollow case in the composition being carried through its entire length, a larger surface would be at once exposed for combustion at the instant of firing the projectile, and thus an increase obtained in the initial velocity.

In reducing this theory to practice, it was necessary that care should be taken that the pressures within the rocket should not be wasted, or, in other words, that the vents should be so reduced as not to permit of a too rapid escape of the gas; and that that portion which did escape should assist the onward motion of the rocket; accordingly, the whole superficial area of the vents in the head and tail are brought as near the area of the vents in the old Hale rocket as possible, consistent with the larger amount of gas evolved; care being also taken to carry the vents in the head in a line with those in the tail, so that the two sets of forces should act equally in all respects.

The new rocket[1] is constructed of a Whitworth steel tube of extra strength, to the shot end of which a collar is welded in, having a hole drilled through its centre and tapped with a female screw for the reception of a piece of wrought-iron pipe, called "the nipple," three inches long; this nipple is the means whereby the head is connected to the body of the rocket, and is also the channel for conducting the gas to the escape holes in the head. The head is of different forms, partaking either of the nature of a shot or shell, but all have a gas cavity in the base with five escapes and their attendant flanges, which latter are in a line with the flanges or vents in the tail; the circumference of the head vents, however, being somewhat greater than those in the tail, and it being necessary that the rotating forces should be equal, the size of the holes and the length of the vents have been reduced. The rocket is driven at a pressure of 90 tons and is afterwards bored entirely through, the base being closed with a disc and tail piece consisting of five conical vents. On ignition, a portion of the gas generated escapes in the old manner by the tail vents, and the remaining portion acting on the base of the shot, is deflected back through the escape holes and against the flanges or vents; thus a rotatory motion, or rather rotating force, is applied to the head as well as to the tail, the effect of which is to cause the wobbling before-mentioned to disappear entirely, and the rocket now leaves the tube or trough with a perfect rotation and steady flight, the deflection is reduced, the range increased by the extra play of gas against the atmosphere, and the trajectory flattened to such an extent that the same range is now obtainable with 10° elevation, which in the old form required nearly 15°.

The increased initial velocity of the new rocket enables it to carry a much heavier shell than that carried by the "Hale," as originally supplied by the inventor, but which was abolished by the Ordnance authorities, and has never been replaced notwithstanding the repeated

[1] For figs. of rockets, patterns of 1876, see page 989.

representations made by numerous officers as to the advisability of so doing. Mr. Macdonald has, therefore, provided his rocket with several different forms of head, all of which have the same arrangement as that in the base of the shot, with which they are interchangeable at the will of the operator; they consist of common, segment, and shrapnel shell, carcass, smoke tail, or parachute light head. The shells are intended to carry bursting charges ignited by time or percussion fuses, concerning which I shall have to speak hereafter.

Hitherto the Hale rocket has not been issued to the services in larger sizes than the 24-pounders, but there is not the slightest reason why they should not be increased to a very great extent. Experimental rockets have been constructed by the Ordnance Department six inches in diameter, and have apparently answered the purpose for which they were intended; but when we get beyond a certain size, we have to contend with difficulties which do not present themselves in the manufacture of those just mentioned. The cylinders would have to be increased to such a thickness that the weight would be greatly increased also, and probably in a greater proportion than the advantage gained, a great difficulty would be found in driving the composition at a uniform density throughout, and the pressure applied to it would have to be materially increased. Up to the present moment the patentee has not decided where the limit shall be drawn, as he has not been called upon to construct rockets of a larger size than 24-pounders; but for siege operations he has patented what he calls his torpedo-rockets or land-torpedoes consisting of a built-up rocket, with a thin metal head, destined to carry bursting charges of 35 lbs. or 50 lbs of gunpowder, gun-cotton, gun-cotton powder or dynamite. In these he has elected to replace the single 12-inch composition cylinder, which would otherwise have been necessary, by several 24-pounder sized cylinders, in order to ensure the composition being driven at a uniform density throughout, so that we have seven columns, "one centre and six surrounding," each of which is formed by two 24-pounder cylinders, driven with composition at a pressure of ninety tons, and connected together by an inside joint, through the centre of which is a communication hole. Both ends are partially closed with metal plugs, the centres of which are bored through and tapped with female screws, the upper ones for the reception of the bolts connecting the columns to the head, the lower ones for the gas-vents forming the tail.

The centre composition column is bored out through the entire length of the composition, but the surrounding ones have a solid portion of composition left in and so placed as to give a great increase in the motive force at that point in the flight of the rocket when such an increase would be of most use. The head or shell is of thin sheet metal, the prolongation of which protects the edge of a wooden bottom attached to its base; through this wooden bottom and into the base of the shell are secured six connecting bolts for the six surrounding composition columns, their lower ends projecting about one inch; the lower surface of the wooden bottom is scored out to receive the gas-cap of the centre column with its three radiating arms destined to carry the gas to the outside circumference of the rocket.

To the head of the centre composition cylinder a metal cap and band is attached, the cap being of the same diameter as the base of the shell, and having holes in it corresponding to the six connecting bolts before mentioned, also an attachment for the centre column; this attachment is hollow and projects sufficiently to allow of three radiating gas-pipes being screwed into it so as to run over the top of the cap, the ends of these pipes being bent down at right angles just inside the band and towards the tail, having their circumference cut away for about two inches at the vent end so as to form flanges for the escaping and expanding gas to act against. The band protects these flanges and forms a front bearing for the rocket to rest on when placed in the firing trough.

A plain cap, with seven holes in it, and band on its circumference, binds the lower extremities of the columns together, being retained in its position by the seven vents screwed through the holes and into the plugs in the base of the columns. The centre vent is a complete piece of pipe, but the six surrounding ones have a portion of their circumference cut away to allow of the lateral escape of the gas; a continuous flange of light metal, forming a connection between the outside vents is then riveted on and completes the construction of the torpedo rocket, which is fired from a trough 12 or 16 feet long, in which it rests on its front and rear bands only, thus reducing the friction to a minimum. The interstices between the columns are filled in with wood, and the whole of the body is surrounded with a cylinder of very thin metal or a sheeting of papier-maché. The gas from the centre column alone supplies the rotating force at the head, whilst that from the surrounding ones all escapes to the rear.

The employment of rockets in siege operations is not a novel idea, for in February, 1875, we find the Ordnance Select Committee making experiments with a 6-inch rocket of the old "Hale pattern" against earthworks, and to demonstrate the effect which can be produced by them, I will call your attention to the results obtained at that time.

Three rounds were fired from a trough 16 feet long—the dimensions of the rockets being as follows:—

Diameter, 6 inches; length of body, 3 feet 1½ inch; length of head, 5½ inches; tail, 4½ inches; total, 3 feet 11½ inches; weight of heads, 7 lbs. 3 ozs.—Total weight, 220 lbs. They were constructed to contain 13 lbs. of damped gun-cotton in a movable head, the charge being detonated by means of a sensitive percussion fuze acting in conjunction with 56 grains of fulminate of mercury.

The first round was fired with 5° elevation at an earthwork 50 yards distant; the rocket grazed the ground 20 yards from the trough, again 4 yards further on, exploding on touching the ground 9 yards from its first graze, and making a crater in the solid ground 3½ feet deep, 8 feet long, and 5 feet wide.

Second round, fired with 10° elevation at a 5-inch iron plate 17 yards distant, struck the plate 5 feet from the ground, bulging it slightly, then glanced off, exploding against the solid masonry, in which it made a hole 6 inches deep and 12 inches across.

Third round was fired with 6° elevation at an earthwork direct, and exploding, made a crater $3\frac{1}{2}$ feet deep and 8 feet in diameter.

These results must, however, be considered as mainly due to the explosive force of the gun-cotton, and not to the momentum of the rocket at the time of impact; for, owing to the very small distance between the tube and the target, they could not have had any great amount of velocity; for it is not till the old pattern rocket has passed through one-third of its flight that it attains its maximum speed. Now that we are enabled to construct them to carry such large charges of explosive matter, and to depend on their range and accuracy in direction, they bid fair to become a most useful weapon in the hands of an attacking force, as their use will obviate the necessity of constructing breaching batteries at all, the great labour and time required to get heavy siege guns into position, with their necessary stores of ammunition, will be economised, and we shall, in fact, be able to say good-bye to the gun, and retain the projectile only. Few indeed are the trophies of English guns that are to be found in the possession of any nation, and we may justly be proud of the fact; but it is as well to remember that reverses happen to all, and one day we may be obliged to quit our trenches, and leave our batteries, or their substitutes, in the hands of an enemy for a time. Should, however, those batteries be constructed for the use of these rockets only, we should not have to regret the loss of guns, which might at some future time be used against ourselves; the very store of projectiles necessarily left behind could, in a few seconds, be converted into so many mines, and, by the agency of an electric fuze and a few yards of insulated wire, be the means of spreading dismay and destruction in a numerically stronger force.

Experiments over the sands at Shoeburyness show that rockets fired from a trough placed on the ground have been known to range 1,000 yards, in no place rising above the height of a man, this too with the old pattern rocket; with the new pattern, its regular flight and flattened trajectory, we could not wish for a better projectile for use against masses of troops, and putting aside the actual destruction caused by it in its flight, the flame and noise of its escaping gas would alone have a most disastrous effect on a cavalry regiment.

We have the opinion of high authorities, such as Lord Napier of Magdala, Sir Garnet Wolseley, and others, as to the performances of these weapons "in their old form" on active service, and all acknowledge the ease with which they can be manipulated and used in positions where it would be impossible to take artillery; to a small expeditionary force they are invaluable, the ease with which a complete battery for support to infantry, or to a naval brigade when landed, is patent to all. Twenty men detached from a battalion would be quite sufficient to carry the troughs or tubes, with the necessary number of rounds for a 4-rocket battery, and thus economise the services of the 100 men who, with reliefs, would be under the number required for the service of four light field guns; for incendiary purposes, and searching high grass and their cover, they have not an equal. I have taken the liberty of thus repeating information which

is by no means new, in order that we may find out the reason why a weapon with such acknowledged good qualities should not have met with more attention, and have been improved upon by those to whom the manufacture is entrusted.

I have, in the first part of this paper, drawn attention to the great uncertainty attending its flight hitherto, both as regards range and deflection, a drawback which, under ordinary circumstances, would have been quite sufficient to prevent its being received into general use in the services, had not its portability and facility of manipulation made up in a great degree for so glaring a defect. In the Hale war-rocket, as at present manufactured, we, however, find another great drawback, which I have not hitherto mentioned, and which, I am very glad to say, has been entirely overcome by Mr. Macdonald, although I believe he is only carrying out Mr. Hale's original intention, and that if the service rockets were made according to the specification in the patent, we should never have heard half so much about their deterioration from remaining in store, and consequent puffing when fired. The pattern at present in use has the case cut out of sheet Atlas metal, moulded into form and soldered together, whereas the new rocket composition-cylinder has no join whatever in it.

The consequence of introducing the use of solder into the construction of the case has been to cause deterioration; the chemical action of the component parts of the composition upon the spelter used has induced corrosion to take place, whereby a space is established between the cylinder and the composition, partially occupied by a spongy substance, which, however, does not prevent the flame from igniting that portion of the composition which ought properly to be the last consumed; an undue strain is thus brought on the case which naturally gives out, and the rocket is a failure. It is difficult to understand why the old specification should ever have been departed from, as the changes introduced have offered no advantages whatever; on the contrary, they have been the source of very great expense in experiments, the object of which has been to overcome the ill effects brought about by the introduction of a soldered cylinder. No matter how inexpensive the necessary correctives may be, they still cost money, and the primary saving of 1*s.* per tube, "which is about the difference "in cost between the soldered Atlas metal case and the complete "Whitworth steel tube," is soon eaten up and vanishes, leaving us with a still defective weapon. You will all agree with the old saying, "What is worth doing, is worth doing well." If rockets are a useful weapon in warfare, and it is worth having them as a means of offence or defence, it is worth having them of the best quality obtainable. Saving 1*s.* per rocket to produce them of such a quality that no reliance can be placed on their action, is nothing more nor less than a waste of public money. On one occasion 13 out of 20 rockets fired for experiment were more or less defective, and yet I can produce some which were driven by the late Mr. Hale at the time of the Crimean war which are in as good a state of preservation now as the day they were first driven.

In thus introducing the Hale-Macdonald rocket to your notice, it has

been as a weapon which we assert overcomes the three great defects existing in the only war-rocket at present in use in both services, viz., great and irregular variation in range and deflection, and a liability to deterioration, with the additional advantages of an increased range and destructive power. Theory alone is of but little use, whilst practice is the sure test of the value of all inventions. It is, however, extremely difficult for a private individual to make very exhaustive experiments with a patent such as that now before us, owing to the difficulty of procuring the necessary range, trained observers, &c.; and although those that have been made up to the present time have not been half as numerous as we could desire, they have still been quite comprehensive enough to demonstrate the advantages that have been obtained, and I doubt if the results given by any number of future experiments will differ materially from those already obtained.

Five 12-pounder Hale-Macdonald rockets, fired from a trough 6 feet long, with an elevation of $8\frac{1}{2}°$, gave a mean average range of 2,050 yards against 1,320 with the old pattern, the mean average deflection in the former being 3 yards against 37 yards in the latter.

The rotation in the old 24-pounder rocket whilst still in the firing trough, is one complete turn in 4 feet; we, however, obtain more than twice that amount or one turn in 18 inches, an acquirement in itself quite sufficient to account for the accuracy in the flight of these rockets as compared with the old ones.

Unfortunately we have not had the means at hand of accurately measuring the initial velocity; the initial strain, however, is sufficient to bend a $\frac{5}{8}$th-inch iron bolt nearly double, and must therefore greatly exceed 375 lbs., which I believe I am right in stating is the pressure exerted on a spring scale by the old pattern shortly after its composition is ignited.

Hitherto I have treated of this projectile only as a rocket or land-torpedo, and of the duties which up to the present time it has been required to perform; but I am now going to speak of it as a weapon which either in one form or the other is destined to take no mean place in torpedo-warfare, both as a means of offence and defence; as an automatic sub-aqueous weapon, and as the best safeguard against the Whitehead, Harvey, and outrigger torpedoes.

Although the interesting battle between the gun and the target is still undecided, and the various phases of it are in nowise less interesting than they have ever been, our attention has gradually been drawn away in another direction, and at the present moment the naval mind at least seems to be fully engaged with the torpedo, its use as a destructive weapon, and the means of protecting our ships from attacks by them.

It is stated in more than one work on ordnance-stores, that "up to "the present time no efficient means has been devised for controlling "the action of rockets under water."

This short notice has always been most unsatisfactory to myself, more especially as I have looked in vain for an account of any experi-

ments which might have been made with a view to testing what range could be procured under such circumstances, or which should justify such a statement, also as a mere accident at rocket practice had led me to believe that, with some slight modifications, the rocket might be made of great use as a sub-aqueous weapon.

In 1871, whilst on the China station and engaged in the usual quarterly rocket practice from the ship's boats at a target 1,500 yards distant, one of the rockets hung in the tube, and as several of the rocket-cases had previously given out when firing them, I ordered the tube to be detached from the boat's side and dropped into the water; the rocket shortly afterwards quitted the tube, travelled under the water for a distance of about 750 yards, then rose to a height of about 6 feet, and eventually fell about 200 yards beyond the target, or at a distance of 1,700 yards, and did not pass wider of the mark than the average of those fired under ordinary circumstances. I was so struck with the performances of this rocket that I determined on the first opportunity of trying a similar experiment, and having a few weeks subsequently to expend some surplus rockets, I fired three rounds under the water with the tube in as level a position as I could secure under the circumstances, bearing in mind that from the absence of other means I had to ignite the composition above, and at once drop the tube to about a foot below the surface.

The first rocket travelled about 250 yards in a direct line, then rose, striking the water again about 600 yards from the boat, when the case gave out.

Round No. 2 could be traced by the smoke rising from the water for about 800 yards, and was then lost sight of.

Round No. 3 I fired towards an island about 800 yards distant, and the case I recovered amongst the rocks, where the small amount of composition still remaining, burnt out. The direction in all three cases was excellent, considering the very rough means at my disposal for directing their course.

With these four results before me, I think that Mr. Macdonald is quite justified in his belief that the rocket may be so constructed as to fulfil the duties of a torpedo.

In 1868 Lord Clarence Paget, the then Commander-in-Chief in the Mediterranean, accompanied by some of the captains under his command, visited Fiume, the chief object of their trip being to get a sight of the Whitehead torpedo, then as now, the novelty of the age as far as torpedoes are concerned. I am not aware that any notice of their visit had been given, but one thing is certain, namely, that on arriving at their destination Mr. Whitehead was very carefully out of the way. With equal care the model was locked up in a shed, of which the keys were unaccountably not to be found; therefore it was impossible that the English Admiral could see it, and every official regretted that such should be the case—"they would have valued his opinion so "highly," &c., &c. My own opinion is that it was never intended that he should see it, and probably the same reason which actuated Mr. Whitehead or the Austrian officials to act in this manner also prevents Mr. Macdonald from giving me permission to give you more

than a very slight account of his torpedo and its capabilities as compared with the Fish; or it may be that he does not consider his experiments with it as sufficient in number to justify my quoting them as guides for the future. The last experiment was a failure, owing to the torpedo being fired in a canal the depth of which was supposed to be uniform, but in which the range was obstructed by a sandbank with only 5 feet of water over it. The result will, however, give you some idea of its capabilities. Five feet long it carried a weight of 100 lbs., representing the destructive charge of 50 lbs. of explosive matter, and a counter-balance weight, and was fired from a trough placed 8 feet below the surface. On ignition it travelled rapidly in a direct line for 250 yards, when it struck the bank and was thrown perpendicularly into the air to a height of over 150 feet, and fell exactly in a line with the firing trough. The case recovered bore traces of the action of the motive force which quite satisfied the patentee, and although there is room for improvement, and some slight modifications may yet be made with advantage before the time when it is finally submitted to the Government for adoption, I trust, that ere long we shall see it being experimented upon by the Torpedo School of Instruction, and accepted as the arm of the future. From my own personal knowledge of its construction, action, and capabilities, I am enabled to state that its principal features consist in the following points:

It is cigar-shaped in form and its size depends on the distance it is required to travel, and the explosive charge it is required to carry. Its minimum speed is three times that of the Whitehead, whilst its range may be made to exceed two miles.

It is fired from a skeleton tube or trough by means of an electric fuze, and can be discharged with equal facility from an ordinary ship's launch or from the side of a first-class ironclad frigate—the special fitting required for it being of the simplest nature, and could be fitted by ship's artificers in a few hours.

It will bear any amount of rough usage, and has not the element of danger present in the Whitehead, in the form of its compressed air at an enormous pressure.

It has no delicate internal machinery or projections liable to injury. Its cost is about one-tenth that of the Whitehead, and its direction is all that could be desired, no deflection whatever being observable in smooth water.

Its centre of gravity can be made to coincide with its centre of form, and its weight regulated to that of the volume of water which it displaces. Its motive power is gas, generated by the slow combustion of a preparation of gunpowder or other composition evolving a rapidly-expanding gas.

I will satisfy myself simply by reminding you that the maximum speed of the Whitehead up to the present time is 28 knots. The limit of its range is 1,000 yards, and its velocity decreases rapidly; it has a tendency to deflect at the end of its range. Its cost is considerable. It requires careful handling and a special staff for its manipulation.

This is the extent to which, at the present time, I am permitted to refer to Mr. Macdonald's system of torpedo offence; and, as regards the defence, I think we need only consider what means should be taken to preserve our ships against the three natures of torpedoes represented by the Whitehead, which is propelled from ship or Thornycroft steam-launch; the Harvey, which is towed into position by ship or steam-launch; and the outrigger, which is carried into contact. As regards torpedoes laid down for the defence of roadsteads or harbours, I do not think that they ought ever to offer the slightest obstacle to the passage of an attacking force, and, as recent operations on the eastern shores of the Black Sea and on the Danube have been carried out on the same system which I had the opportunity of proposing four years ago, as being, in my humble opinion, the most efficient means, and have thus far enabled the Turkish squadron to remove all obstacles, I think I am justified, on the present occasion, in limiting my remarks to the three natures just mentioned, and which cannot be dealt with in the same manner.

I believe I am right in stating that, up to the present time, of the numerous plans which have been advanced as means for protecting our ironclads from attack by submarine torpedoes, those found to be most efficient are—the use of the electric light, which gives us the means of unveiling the operations of an enemy who enlists the darkness of night to cover his attack by fast steam launches or other vessels, carrying Whitehead or outrigger, or towing Harvey's torpedoes; a *cordon* of patrolling Thornycroft or other fast steam launches to guard the approach, and which may be considered as the first line of defence; the guns of the vessel as the second, and a continuous circle of nets, trellis-work or metal Venetian blinds, supported by struts at the distance of a few feet from the ship's side, and extending a certain depth below the surface of the water, as the third or inner line. By an efficient use of the two first means, no enemy ought to be able to enter, unseen, that circle which is the limit of his destructive power, namely 1,000 yards, or the extreme range of the Whitehead, and at double that distance his attack ought to be unmasked, after which his further progress must be prevented by the ship's guns or other means at our disposal. Should, however, a combined attack, by numerous fast boats, enable one or more of these to penetrate unseen or unimpeded, we have to trust to the net, metal screen, or line of booms surrounding the ship.

It is at that point where the attack has been discovered by one of the patrolling steam launches, that Mr. Macdonald steps in and advocates the use of his smaller rockets as offering the most efficient means wherewith the patrols shall be able to destroy the enemy. The patrol, to be efficient, must be one of the "Lightning" class, but somewhat smaller, or fast steam gigs (constructed by the same firm, and of which every ironclad ought to carry two), might supply the requirements; but whatever they are, they require to be swift and to be armed. Now, to place the lightest gun we have in the bow of one ot Messrs. Thornycroft's steam launches, with the necessary store of ammunition in the body of the boat, would be throwing away one of

the advantages obtained from their use, for the speed would at once be sensibly diminished, by the boat being out of trim and from the increased immersion of the hull. Where the weights have been so nicely calculated as to prohibit coal even being carried beyond a very limited quantity, it is not likely that we should be able to carry a gun, and yet a projectile of some kind we must have.

That projectile we have ready to hand in the 24-pounder or smaller Hale-Macdonald rocket, carrying in its head a bursting charge of gun-cotton, gun-cotton powder, or dynamite, and for the discharge and directing of which we should, in this case, be able to dispense with the tube now used at sea, substituting in its place two thin guide-rods of metal, travelling on a pivot placed in the metal deck of the Thornycroft launch or gig. Upon the metal deck the back fire of the rocket would do no harm, whilst the two or three individuals forming the crew are upon all occasions under cover of a screen, and would therefore be free from danger. Three pounds of gun-cotton, which can be carried with ease in the head of the improved 12-pounder rocket, would be quite sufficient to send any outrigger torpedo-boat to the bottom, or, as they can be fired with equal effect below water as above, at short distances, there is no reason why they should not be so used, using an electric fuze for their ignition and skeleton tube, weighing a few pounds, from which to direct them. The actual weight of the so-called 12-pounder is about 18 pounds in its new form, and I humbly suggest that 12 rounds, or 216 pounds, with a small additional weight for the skeleton tube and electrical battery, amounting in all to about 250 pounds, would not be a very great increase to the weights actually necessary in the service of the Thornycroft. I trust that this short paper will be the means of introducing the rocket to you in a new light, and that, by aid of the valuable opinion which is always to be obtained on similar subjects from the members of this Institution, it may be still further perfected and take that position as a projectile to which I firmly believe it is entitled.

A desire was expressed by some of the Members of this Institution that I should entitle my paper—"The Gun, Ram, Rocket, and Torpedo;" but considering the enormous amount of matter requiring to be touched upon in such an essay, the limited time and the impossibility of successfully treating such a subject therein, I have elected to treat one division only, and trust that in its present form it may be the means of drawing out in the discussion that is to follow some interesting comparisons between the other arms mentioned in the proposed title, and with this in view I may, perhaps, be permitted to add some few remarks concerning the latest features in torpedo-warfare on the Danube and in the East generally, as they may assist us in finding out how far the rocket may be introduced as an auxiliary.

We are now at a most eventful period in the history of war, a time when two great armies are operating against one another; armed with weapons only recently introduced, or which are now for the first time on their trial in active service. Amongst these, the description which is most likely to hold public attention is the torpedo—the Whitehead and Harvey descriptions of which now appear for the first time on the

theatre of modern warfare. After weeks of preparation on both sides, which have given every opportunity for defending approaches by means of these submarine mines, either mechanical or electrical, we find vessels daily passing uninjured up and down the Danube, or attacking maritime fortresses, the waters of which are understood to have been defended by this meaus. This fact alone I maintain must have done much to undermine the belief of those who are supporters of the torpedo-defence theory. If a nation so utterly devoid of energy and resource as the Turks are known to be in their higher official grades, has been enabled to remove or ignore these obstacles, how much less likely is it, that with our Officers carefully trained in all branches of this special means of warfare, we should be prevented from operating successfully under similar circumstances?

Two successful cases of torpedo-attack have alone been chronicled: one by a Whitehead, the other by a mine carried to a ship and attached to her side or bottom under reported circumstances which cannot command our credence. Putting aside all such sensational stories as that of swimming off with the torpedo in a rapid stream so as to avoid detection, we cannot help admiring the pluck of those who were successful, no matter by what means that success was obtained, and the feat was one which would have commanded admiration even in our own service. Looking at it, however, in another light, we find that apathy and treachery are the allies whose co-operation alone rendered success possible. In the first case the vessel was at anchor, and without the slightest attempt at defence of any kind, such as nets, &c.; in the second a traitor (probably bought over by Russian gold) would not fire on the approaching enemy or signal his presence to a comrade in danger. Can we, under the circumstances, attach any value to these two demonstrations of the use of the torpedo? I say not; for we are well aware of the effect of the explosive charges they can carry, and the destruction that can be done thereby. What we want to know is, if they will be succeesful against a well-considered defence. These two disasters seem to have taught the Turks a lesson, for since that time they have taken some means to protect their ships, both whilst at anchor and also when under way. At the Sulina Mouth of the Danube, their four ironclads whilst at anchor were protected by a complete cordon of ships' boats (with half crews to act as sentries and to repel any attack that might be made), and attached by means of a chain; by this means an attack made by six torpedo boats was repelled, two of the attacking force being swamped and their crews made prisoners, whilst the remaining four escaped and ran away to fight another day. Owing to the boats and half crews being in the range, the ships' guns were neutralized, and the Commanding Officer did not like to fire case for fear of killing his own men. Here we see the use of the rocket demonstrated, for if the chain-supporting boats had been armed with them, Hassan Pasha might have settled his score with the whole of the six attacking boats. At Suda Bay, booms were substituted for the boats, and, moored at a distance of 1,200 yards from the ships, they carried an electric communication with the different ships, whose guns were so laid as to command different portions of this line of defence;

by this device any particular point touched was at once communicated, that is to say, if the wire was broken, as it in all probability would be, either by the torpedo-boat's bow or screw. This system has only been used as yet in exercise, it remains to be seen how it will succeed when an attack is actually made.

As a comparison between the gun and the rocket for arming the Thornycroft steam launches, gigs, &c., we find that the saving nearly equals the weight of the gun-carriage, and slide.

Nine-pounder 24 rounds of shell	216 lbs.
Charges and powder case	47 lbs. about
Total	263 lbs.
24 six-pounder rockets H. M. 8 lbs. 13 ozs.	$211\frac{1}{2}$ lbs.
Hale-Macdonald firing instrument	47 lbs.
Total	$258\frac{1}{2}$ lbs.

The gun-carriage and slide, tackles, &c., may be said to weigh 843 lbs., to say nothing of the crew required to work, and the fact that a boat's gig could not possibly carry it.

Captain R. A. E. Scott, R.N.: Being asked to speak, I am merely going to start the discussion, because there are many Officers present much more competent than myself to speak on this subject. While fully concurring in the value of the Whitehead torpedo, and the skill with which it has been developed, I think it has deficiencies to which I should like to call attention. The Whitehead torpedo is discharged from off its carriage by compressed air, contained within tubular reservoirs, forming part of the carriage. This air-pressure is applied behind the torpedo, but the amount of push given cannot be very great, or it would be doubled up. The torpedo, before being placed on its firing carriage, has first to be filled from a reservoir of air, for which purpose it has to be taken perhaps to one end of the ship, and then when it is filled, has to be wheeled along to its firing carriage at the other end; it then has to be put upon its carriage, and is fired, being pushed out at the port by the compressed air behind it, and is then actuated by its own engines. Of course it can only be given a certain small amount of push, and consequently only a small amount of initial velocity. We know that if the ship be moving at the moment when the torpedo touches the water, it will be somewhat deflected from the straight line—the motion of the ship will be impressed upon it; nor can the torpedo be pushed so fast but that the motion of the ship will greatly affect it. This shows how necessary it is to have a very great projectile speed in order to insure great accuracy. Hitherto the trials of the Whitehead torpedo have been principally in smooth water; we have had very little experience of discharging this torpedo in a seaway, when possibly the waves would deflect it in a still greater degree than the motion of the ship. These deflections have an important bearing upon the use of the fish-torpedo because they indicate that you cannot safely use it when in company with friendly ships. With a squadron of vessels around you, you could hardly tell when to fire the Whitehead, or in what direction it would go, and he must be a daring commander indeed who, if hostile vessels were advancing to meet him, would venture to fire such a weapon across his own squadron. I point out this danger, in order to show how very important it is to have a high projectile speed, for the higher the speed the more you lessen the dangers referred to. If you get three times the speed of the Whitehead, you would, I believe, only have one-third of the danger, and in that fact, viz., high speed, consists the superior value of the gun as compared with any torpedo. The rifle projectile goes straight to its object, being only appreciably influenced (and that in a very slight degree) by wind. Looking at the fact that if you fire the torpedo with a vessel going through the water, it

must necessarily be deflected, it stands to reason that you must stop your ship if you want to fire accurately. A large ironclad with no way on her in the presence of a hostile squadron is exposed to the very great danger of being rammed, and therefore it is very important in using such a weapon as the Whitehead torpedo, to fire it from a boat, because a boat can be stopped easily and go ahead again very quickly. A comparison between the Whitehead and rocket torpedoes shows that the latter is propelled by the most powerful agent known, that is, the gas generated by the combustion of gunpowder, and as a consequence it goes at immense speed, and does not, like the Whitehead, require the addition of delicate machinery. The result of the rocket torpedo's high speed entails another very important advantage, which is that if it strikes an iron ship's bottom, it would go through. I believe this rocket would penetrate a couple of inches of iron, but I much doubt whether any Whitehead torpedo would go through half that thickness. We may, however, in a short time, be building vessels with a thick outer skin and with an inner skin considerably removed from it, which will tend very much to prevent the injury the Whitehead torpedo is now expected to cause. I really do not see how such a weapon as a powerful rocket torpedo can be stopped; in fact, you cannot make the ship's bottom thick enough to withstand the blow due to the great speed of this formidable missile, which can be easily fired from any boat. You would not even require to have a carriage filled with compressed air, from which to discharge it, and would thus avoid a source of danger to the crew using the missile. The Whitehead, on the contrary, requires the most careful manipulation throughout, and if the propeller chances to touch on going over the gunwale, the Whitehead would be at once deflected, and no one could tell in what direction it would go. This rocket is, however, smooth and without propellers, and may be safely launched at once, and even were the ship going through the water, there would be comparatively little deflection. There is another consideration, which is of national importance, in that, under the present circumstances, we must, in self-defence, utilise the enormous but dormant power of our Mercantile Marine, and what could be simpler as a weapon for this vast merchant fleet than this rocket, granting that it be thoroughly developed? I do not, however, think that any private firm will be able to develop it fully, because no firm has the trained observers that are necessary to advise as to faults, and where improvement should be made. It is no use to have experiments unless the persons sent to watch them are able to judge of the causes of failure or want of perfect accuracy. I have now started the discussion, and have endeavoured to show the importance of having such a simple and easily handled weapon as that brought before us by the lecturer, a weapon which can be used from our lightest and fastest boats, and could be quickly made a very effective naval weapon. Lastly, let me say a word as to keeping off the fish torpedo by nets and those other appliances that have been devised; these are, I think, out of the question in war, nor would an active enemy be kept off by such means. I do not wish to make any reflection upon what other nations have done, but I feel quite sure that if our Officers had been in the Danube during the present war very few of the Turkish vessels would have been left there. The handling of torpedoes filled with large charges of violent explosives gives full play to individual dash and courage, for their successful employment depends upon these qualities, combined with coolness and skill in individual men; in fact, the introduction of the torpedo into naval warfare has given far greater opportunity for the display of these high qualities than has hitherto been found on board our valuable ironclads, which I hold are sea-keeping vessels, and neither intended nor adapted for river warfare. We must have a squadron for rivers and a squadron for sea, and to a nation such as ours, with colonies all round the world, the fact of these missiles having been introduced, is infinitely more important than to any other nation, for besides having given us a ready means of defending our own shores and our vast mercantile fleet, it has also greatly added to our facilities for carrying any combat to a successful issue.

Rev. C. Meade Ramus, M.A.: I should like to ask the lecturer if he has made any measure of the actual driving force of the rocket. The difference between the Admiralty and myself is that my rocket does not develop sufficient driving force I have their statement of the force, which is that a 24-pounder burns forcibly for 1¾ seconds, and produces during that time 325 pounds. My object in coming here to-day was to ask Captain Cole if he could give me the force that his rockets produce

measured in the same way. Of course the distance to which a rocket is carried depends upon that force and the *time* in which it is developed. If these could be accurately measured, we could measure everything else.

Lieutenant ARMIT, R.N.: A remark has been made that it is difficult to stop a torpedo. I have for some time past turned my attention to the cause of the effect produced by the torpedo, and have endeavoured to ascertain whether that effect could be conquered, *i.e.*, whether it is possible to prevent the torpedo blowing a hole in the ship's side. I think if you study the question as I have done, you will admit that there may be a chance of preventing the torpedo from injuring even the weakest vessel when the explosion takes place at her side. The cause of the torpedo fracturing her side instead of blowing up the superposed water appears to me to be that, behind the torpedo you have unlimited water. If the torpedo strikes the ship five feet from the surface, then, on a line parallel to the surface, and behind the torpedo you have unlimited water, which is incompressible; therefore, you have unlimited resistance to the expansion of the gas in rear of the torpedo. You have also unlimited resistance in the water between the torpedo and the bottom or bed of the ocean or river, and if you complete the parallelogram of these forces, the diagonal, being the resultant of these forces, passes through the ship's hull. The only question seems to me to be, how can you deflect the line of fracture from the interior to the exterior of the ship?

The CHAIRMAN: The subject of the lecture is the rocket. So far as any remarks may elucidate the subject, of course we shall be glad to hear you, but our object is to discuss the rocket.

Lieutenant ARMIT: Whatever torpedo you use under water, I believe its effect can be counteracted by merely altering the form of the ship so as to make the resultant of the forces brought to bear on the ship's side pass outside instead of inside the ship. If the side of the ship is at such an angle to the explosion that the line of fracture or of least resistance passes along the side instead of through the ship, you will not fracture your ship's side at all, and then your torpedo will be useless.[1]

Mr. SCOTT RUSSELL, F.R.S.: I should have been very glad to have heard the question that Mr. Ramus asked answered at once, because I think the whole gist of the superiority of this kind of rocket to what we call the air-propelled rocket under water is very much the question of what is the efficiency of this propelling power. Now, I am myself a great lover of rockets; I think them most efficient weapons for a great many purposes. I ventured here one day to say that, according to experiments I had made, I was prepared equally to put a shell into a ship from above, and a shell into a ship horizontally, and a shell into a ship from below, and that from a great distance. I have made many experiments with the same propelling power that you have here in the rocket. I have a great belief in the propelling power of the rocket. I do not think the subject is as yet thoroughly understood. I have never yet heard it thorougly expounded. I do not know any book which I can consult where I can find what one pound of propelling rocket-powder in a rocket will produce in the shape of what we engineers call mechanical result. I hoped to-day that the author of this paper would have told us exactly what each pound of propelling powder in the rocket would carry, how much velocity it would give in a given time, how much space it would take to get that velocity, and then we could tell all the rest as to where we would land the rocket and what we should do with it; whether we propelled it to go to the bottom of the ship under water, or horizontally under water, or horizontally over water, or meant to put it vertically down through a ship's deck—all these things we can do if we set about it, and I am delighted to hear that a set of experiments are going on, on, I believe, a new system, which I dare say will lead to very good results, but I hope the hint that the Government is the proper person to do this, will be taken up. I must confess my own scepticism on the point as to whether those two sets of openings for propelling the rocket at two different places are in any way better than the propelling power coming entirely out behind. I have made ships which have

[1] To render the explosion harmless, and to prevent the ship being injured, is extremely easy, and can be done without detracting in any great degree from her speed or handiness.—R. H. ARMIT.

had two propellers, one in the middle of the ship and one in the rear of the ship, and I never found that ship with the two sets of propellers a bit better propelled than that same ship with one propeller at the end or two propellers at the side, or anywhere you like. So I cannot see the good of the new complication of making this rocket with two sets of propellers. But I am of opinion that that increased propelling power, by having a larger quantity developed and pushed out in greater quantity behind, is an increase of force, but that that increase of force is better gained by shifting it, is not my opinion. On the contrary, I think it is worse gained, and I see a great many disadvantages in shifting the propelling power from the rear to any other part. In the meantime, I beg to say, in my opinion, a great deal of new information has been given to us in the paper, and I think a great deal of wisdom is shown in the general explanation, and in the general announcement that the material necessary to carrying a shell a given distance with a given speed, never mind whether below or above the water,—the material in the shape of the Hale rocket, the propelling power in the shape of the Hale rocket, is far more simply obtained, that the material is far more economical, and that out of a given means you get a far higher result by the Hale rocket than by any of the methods that are now adopted for the propelling of shells by other means. Therefore, I would recommend the rocket to the most careful attention of men who are making war the subject of their study, at this most important moment, and particularly I should like the data that we want, to be obtained for us, for the practical use of the rocket under water and the rocket over water, that we should get all the data by which to know exactly how much power would produce so much result. Allow me to sum up by saying that I believe that those small vessels are our great protection against torpedoes of any kind; secondly, I think that those small vessels will be a great instrument for training our sailors to modern gunnery and clever seamanship; and, thirdly, I believe small vessels will be far more efficiently armed by rockets of this kind than by many of the modern weapons which it is proposed to put into them.

Captain COLE: In reply to Mr. Ramus, I think I stated in my paper that, from want of proper means, I have been unable to give a proper statement of the force of the rocket. The force of the old rocket was stated to be between 360 and 375 lbs.; that was obtained by attaching the rocket to a spring balance. Now, we have had no means of doing that, but, on firing a 12-pounder rocket ten days ago (to test the composition), the head was rested against a five-eighths of an inch iron bolt; we bent that bolt nearly double. The strain, being a constant one in both cases, was evidently very much greater than 375 lbs.

Mr. RAMUS: Time is the other element.

Captain COLE: I must tell you that the rockets are driven with a different composition to that which was used in the service-form of rocket. In the service-form of rocket the time is ten seconds in the 24-pounder and eight seconds in the 12-pounder, the maximum force is at about two-thirds; the time of flight, that is about six seconds after ignition in the one, and five seconds in the other. The composition with which these rockets are driven gives one second shorter burning in both cases than the service rocket, and it is a stronger composition. Here you have three compounds which are really the ingredients of gunpowder—sulphur, saltpetre, and charcoal. It depends entirely in what proportions you mix these together. You can get a certain amount of work out of it, and the question is, where is the maximum? It is not to be supposed that the Government fell very far short of the true proportions when they made a rocket composition which has been used in rockets for many years. It has not varied at all. The only thing is, Mr. Macdonald has slightly altered the proportion as used in the service rockets. The proportion in the service rockets is saltpetre, 70; sulphur, sublimed, 16; charcoal, powdered, 23. In fact, it is gunpowder in another form; but Mr. Macdonald's composition is somewhat stronger, and, being somewhat stronger, it burns somewhat more rapidly; it evolves more gas. I may state that a gentleman known to myself, Mr. Punshon, is quite prepared to introduce improvements into that composition, which he says will materially lengthen the combustion; but, at all events, the Government at the present moment have no better composition than that which is obtainable out of the same ingredients.

With regard to the remarks made by Mr. Scott Russell, I am very diffident in

replying to anything set forth by a gentleman of his experience. But, with regard to driving ships with two sets of propellers, that may be very well, but you must remember, first of all, that ships do not rotate; they are floating in a liquid, of which the natural resistance is equal on both sides. The only thing is, you there exert a stern pressure. It depends entirely whether it is a dragging or a pushing force—whether it is a paddle-wheel which drags the ship or a propelling force, like the screw, which worms its way into what is not a solid, but which is the next thing to a solid. The great difference is, that in these rockets, as you add a material weight to one end, the patentee considered that it was only advisable that he should, at the same time, add a rotating force at the head; and there is an experiment here which I have placed before your notice. It was in the first of these series of experiments of rockets made by the War Department. They were all fired from a trough sixteen feet long, and at fifteen degrees of elevation, consequently the fore part of the rocket-tube or trough must have been some feet from the ground, but yet the rocket actually struck the ground twenty yards from the mouth of the tube. It must have been almost impossible for it to touch the ground at so short a distance from the tube unless it had been deflected downwards; in fact, by the time it had left the mouth of the tube it must have been pointing downwards. I am certain that, at the time the rocket actually left the last portion of its bearing, instead of the axis having an inclination of fifteen degrees to the plane, it had five degrees depression. That was simply through a want of rotation at the head, for some reason or other. It was propelled with a composition by which a sufficient force of gas was not generated; it did not leave the tube with sufficient velocity, and therefore the action of gravity on the heaviest portion—the head—at once caused that portion to droop, not having sufficient velocity, or a sufficient rotating force. Now, if you have a rotary motion added to the head, and they are both acting in exactly the same point in the line, the line drawn from the point of one flange to the point of the other will be found to coincide with the axis of the rocket. It is like putting, we may say, the force right throughout the whole axis, only it is distributed in an equal force at the head and an equal force at the rear. In the instruction ship at Portsmouth, twelve or fourteen years ago, they used to tell you that the sole momentum in the rocket arose from the difference in the pressures on the head and on the base. They say you have a closed cylinder, an expansive gas inside; the lateral pressure is the same; the pressure on the head and base is the same; if you have a way of escape in the base, you get a preponderance of force in the head, and therefore the onward motion. That theory may be right to a certain degree, but there is a very great force in the rocket that has always been ignored, and that is the expansion of gas on the atmosphere, and also in a sub-aqueous weapon. I maintain—of course I cannot divulge the means whereby you obtain this force most advantageously—the expansion of the gas when it is escaped through these holes, after giving the radial motion, gives a very great onward motion, and when you come to use it as a sub-aqueous weapon, you will find the resistance offered by the water is greater than that offered by the atmosphere, and therefore you will get a much greater rate of speed out of the sub-aqueous rocket than out of the one used in the air. In other words, speaking comparatively and considering the greater resistance, you will find, taking the same tube, the same component parts of the composition, but mixed in different proportions, if you drive it through the water, you can make it go much farther than when you drive it through the air. True, the resistance to the head offered by the water is greater owing to the density, but from the same cause, the water being a denser medium, I am enabled to use a much slower burning composition. The composition burns longer than in the air, and I get a better range than I could in the air.

Mr. Scott Russell: You get a much larger mechanical power, but then you have a much greater resistance to overcome.

Captain Cole: For short ranges, I can simply make a sub-aqueous torpedo, out of the same materials, do a great deal more than I can with the present war-rocket exploded under water. I have mentioned the difficulty of getting the range. On two different occasions this week we have been down trying to fire these rockets, at the request of the Government, at Shoeburyness, and making experiments with different compositions. We were going to fire several rockets. We fired one rocket

with five degrees of elevation, but down came an artillery officer directly:—"You "can't fire here; there is fifty tons of powder a little further off; we cannot possibly "have rockets fired here." The trial was made at another place, and 6,000 yards were measured on the sand, but then they found the tide was rising, and the operator who went down, not only with great difficulty saved the apparatus, but very nearly got drowned himself. This one rocket which was fired—a 6-pounder, with five degrees of elevation—attained a 1,200 yards range direct, and a very good rocket it was. That 6-pounder weighed 8 pounds 13 ounces; in other words, it was equal to the 9-pounder Armstrong gun, with its shell arrangement. The old 9-pounder rocket, without shell, fired with fifteen degrees of elevation, showed a range of 1,536 yards; but it had a deflection of thirty-eight feet. Now, if you have not gained anything by giving this extra rotation to the head, I do not think the extra increase you get in the strength of the composition made out of the same ingredients could be productive of these good results, unless the rotation of the head had something to do with it, because you find the deflection in one case is only three yards as against thirty-seven in the other. Those improvements must be due to something more than the alteration in the strength of the composition.

Mr. Scott Russell: To higher velocity, perhaps.

Captain Cole: Then you gain greater improvement in the composition, but you have not increased the quantity; you have really diminished the weight.

The Chairman: I am sure we are very much obliged to the lecturer for the information he has given us in so able a manner.

Figure 1 is a longitudinal section of a shell rocket constructed according to my Invention; Figure 2 is an elevation of a part of the same.

a is the rocket tube of wrought iron. *b* is a cast-iron collar riveted into its fore end. *c* is the rocket composition; it is pressed by hydraulic pressure into the case and then bored through from end to end, as the Drawing shows. *d* is the tail piece; it is riveted into the tube *a* after charging. An end view of the tail piece is shown at Figure 3; it is provided with five apertures, each having a semi-cylindrical flange or half tube on one side and a central aperture, as shown. *e* is the head; an under side view of it is shown at Figure 4; it is a tapped hole at e^1 into which the wrought-iron pipe *f* is screwed. At its other end the pipe *f* is screwed into the collar *b*, and the pipe thus serves to connect the head with the body of the rocket. When the composition in the body is ignited the gases in part escape by the apertures in the tail piece, and in part they pass through the pipe *f* into the head and issue by the inclined orifices e^2, which, like the orifices in the tail piece, have each a semi-cylindrical flange or half tube on one side, as shown. *g* is the base plate of the shell, it is screwed on to the pipe *f*. *h* is a cylinder of thin metal forming the charge case, it is placed over the pipe *f* and kept concentric with it by the wooden discs *i*, *i*. *k* is the wooden tube surrounding the pipe *f*, and serving to keep the powder or other explosive with which the shell is charged out of contact with the pipe. *l*, *l*, are cast-iron rings fitting over the outside of the cylinder *h*; these rings are cast with notches at intervals around the interior to cause them to break into a number of fragments when the charge explodes. *m* is the top plate of the shell, it is of cast-iron and is screwed on to the pipe *f*. *n* is an ordinary time fuze inserted through a hole in the plate *m*. *o* is a disc of wood interposed between the plate *m* and the head of the shell; it is grooved at o^1 to receive a fragment of quick match to light the time fuze immediately the fire commences to issue from the head.

Figure 5 is an elevation, and Figure 6 is a longitudinal section of a portion of a shrapnel shell rocket. The pipe *f* in this case is shorter, it receives over it cast-iron rings *p* and wooden discs *q*. The head *e* is of a different form from that used in the segment shell rocket, but it is provided with similar apertures for the escape of the gases generated by the burning of the rocket composition. e^1 is a flange on the head to which is riveted the wrought-iron tube *r* forming a chamber which receives within it the bursting charge *s*, enclosed in a suitable case and penetrated by a time fuze *t*. This fuze is inserted through a hole formed for it in the head, and it is ignited when the rocket is fired by flame issuing through a small

vent e^3 formed for the purpose. s^1 is a pad of felt to protect the bursting charge when the head *e* becomes highly heated. *u*, *u*, are shrapnel balls imbedded in sawdust and pitch or such like materials. *v* is a cover plate riveted into the front of the tube *r* to secure its contents. *w* is a wooden cap to give the fore part of the projectile a suitable form for flight. This cap in place of being made of wood may be formed of hollow metal, which may be filled up with wood. Rockets of similar construction but without shells may be used for carrying lines for saving life at sea.

IMPROVED WAR-ROCKETS, PATTERNS OF 1876.

FIG. 1.

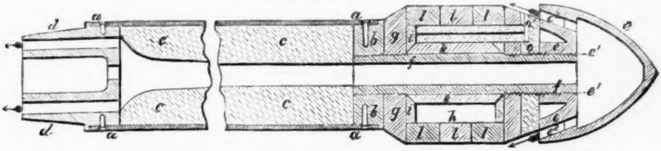


FIG. 3.

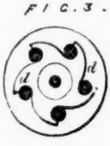


FIG. 4.

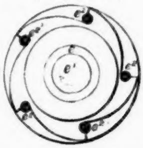


FIG. 2.

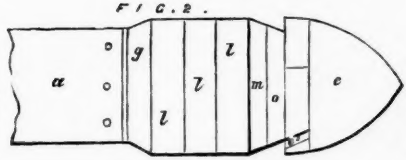


FIG. 6.

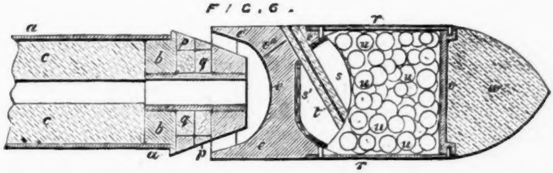
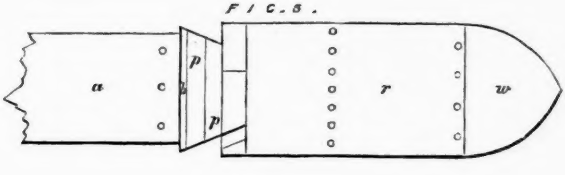


FIG. 5.



LECTURE.

Friday, 29th June, 1877.

GENERAL SIR WILLIAM J. CODRINGTON, G.C.B., Vice-President, in the Chair.

ON THE PROGRESS THAT HAS BEEN MADE DURING RECENT YEARS IN DEVELOPING THE CAPABILITIES OF CAVALRY.

By Capt. F. CHENEVIX TRENCH, 20th Hussars.

THE services rendered by the German cavalry to its own side during the Franco-German campaign, have long been matters of history. The manifest importance of the new *rôle* that the cavalry will for the future be called upon to play, and the weighty issues that must in all future campaigns be dependent upon the proper fulfilment of the new and enlarged sphere of duties that will in nine cases out of ten fall to its lot, have amply sufficed to soothe and comfort the *amour propre* of the cavalry arm, whose pride had been somewhat wounded by its own palpable failure to achieve any great results on any of the battle fields or campaigns that had but shortly preceded the Franco-German war. With the experience, however, of that war as a guide for the future, it is scarcely probable that in any future campaign any leader of a cavalry division will, if he is a capable man, have any cause to think that the cavalry force which he commands is called upon to play a merely secondary or subordinate part. But, however much the Germans, aided as they unquestionably were by the inefficiency or supineness of their opponents, were able to achieve in 1870, it is certain that they themselves had long recognised the fact that what they did then was but a feeble first attempt to develop the utility of their cavalry. No one who has discussed the subject with German or continental officers, who is at all conversant with what has been practised and attempted at the various cavalry manœuvres on the Continent during the last few years, who has read what has been written and suggested upon the subject, or who is aware of what has been done or is doing to improve the organisation or to develop the capabilities of the cavalry arm in various continental countries, can fail to

see that the successes of the German cavalry in 1870 only faintly foreshadow what it is hoped in any future campaigns to achieve. In other words, both in Germany and elsewhere a great stimulus has of late years been given to the organisation, the instruction, and the exercises of cavalry. In whatever direction we turn, and to whichever of the great continental armies we look, there are, even to a casual observer, abundant evidences of all this. The more obvious and primary cause of it is, of course, as already remarked, the campaign of 1870–71, which afforded so clear an illustration of the advantages which an efficient cavalry may secure to its own side, and of the loss and disaster that inefficiency and supineness in this arm may entail on the other. But there have also been other, though it may be secondary, causes at work, which have powerfully contributed to induce continental armies, since the Franco-German campaign of 1870–71, to endeavour to develop to the utmost the capacities of this arm. These causes may be broadly stated as follows:—It has needed no very keen insight upon the part of those interested in this question to perceive that so one-sided a campaign as that of 1870 (so far as the efficiency of the cavalry arm is concerned), is scarcely likely to occur again, and that in the next campaign between any of the great continental Powers, any great battles will probably be preceded by a series of contests between a tolerably well matched force of cavalry on either side. Secondly: the experiences of 1870, and the subsequent criticisms of military writers upon the sins of omission and commission of which the German cavalry, in spite of their brilliant achievements, were guilty, served to open out and to show a more enlarged *vista* of the manifold duties that the cavalry of any great army, more especially at the outset of a campaign, would henceforth have to perform. Among such critics, Verdy du Vernois may be cited as having done especially useful service, by his work on the cavalry division, in which he clearly illustrates and sets forth what, under definite supposed circumstances, a cavalry division operating in front of an army might be expected to do. Thirdly: in every case where the territory of a great Power is only divided from that of a powerful neighbour by no obstacle more formidable than a mere line upon the map, it has been clearly seen that in the event of a declaration of war between two neighbouring States, the army that can first bring its cavalry into the field, place it on its frontier ready for action, and at once make use of it in the most approved modern fashion, may be able, at any rate at the outset of a campaign, to secure very great advantages for its own side, not the least of which will probably be the *prestige* that invariably attaches itself to a series of first successes at the beginning of a war. In other words, both for the cavalry of the army of invasion, and also for that of the army that intends to defend its own frontier, rapidity of concentration will be all-important. For all these reasons it is not to be wondered at that no pains have been spared by continental Powers to have their cavalry so organised as to be constantly ready on the shortest possible notice to act. In some cases, as in the Russian army, its whole organisation has been entirely re-cast during the last few years; in others, such as in the German army, successive alterations and improvements

have been adopted, until a point of readiness has been attained which is as near perfection as possible. And this necessity of being ever in readiness has not only influenced the organisation of cavalry, but in the great continental armies has necessarily determined the very *locale* in which large bodies of this arm must be quartered in time of peace. Let any one examine the conterminous frontiers of some of the great Powers, and let him ascertain and mark the number of the cavalry regiments quartered in the garrison towns on each side of the frontier, and he will see that their number is oftentimes so great at these points, that they can only have been placed there in order to be as near as possible to the spot where there services would, in the event of an outbreak of war, be immediately required. Take, for instance, the case of the conterminous frontier of Germany and France, where, as we all know, each side watches the other with a very jealous eye. Within 60 or 70 miles of the frontier, France has 15 cavalry regiments, *i.e.*, according to the French organisation, two and a-half divisions of cavalry, while Germany on her side has 10 regiments. Within 120 or 130 miles of the frontier, the balance of strength in cavalry is somewhat reversed in favour of Germany, inasmuch as within this distance that Power has 20 regiments of cavalry, while France has only 18. But I see now that only the other day the Emperor of Germany issued an order to the effect that two more cavalry regiments were to be quartered in Alsace.

As a second instance of what has just been pointed out, I will take the cavalry of another great military Power, one to which much interest attaches at the present time, and one, too, which has been most energetic during recent years in reorganising her cavalry, I refer, of course, to Russia; and I will endeavour to show what changes she has recently thought it necessary to make in the distribution of her cavalry force. Up to within fifteen or twenty years ago, Russia had no great reason to be specially apprehensive for the safety of the western, *i.e.*, the European frontier of her empire. The weakness of her neighbours, the paucity of railways, and the immense distances that an enemy's forces would consequently have to traverse ere he could strike an effective blow, were sufficient to guard her against any great fears upon this score. During the last ten or twelve years, however, the situation has, as all the world knows, materially changed. This altered state of affairs has induced Russia to take such measures as will enable her to guard against any sudden inroad being made against the most vulnerable portion of her vast empire, viz., the immense extent of her western frontier. With this view, very much of her cavalry, which had before been always quartered in various interior parts of the empire, has now been echeloned on or near her western frontier. In other words, it is in time of peace so quartered as to be ready instantly for any contingency that may occur. According to its new organisation, instituted in 1873 and 1874, the Russian cavalry comprises some 14 divisions, of 4 regiments each. Of these 14 divisions, 11 will be found to be permanently quartered in proximity to her western frontier.

If you look at the acccompanying map, you will see how these divi-


BALTIC SEA
Gulf of Riga
PRUSSIA
Kovno
Suvalki
Lomza
Byalostok
POLAND
Kalisz
Tchentokov
Zamosc
Doubno
RUSSIA
AUSTRIA
Umane
Elizbetgrad
Kischeneff
Roumania
River Danube
Crimea
BLACK SEA
TURKEY

J. Jobbins

sions have, since the reorganisation of the Russian cavalry, been disposed.

Beginning from the north, the following are in ordinary times of peace the head-quarters of the divisions of the Russian cavalry. Four divisions, viz., the 2nd, 3rd, 4th, and 6th, are permanently stationed at Savalki, at Kovno, at Byalostok, and at Lomza respectively. These are in the neighbourhood of the Prussian frontier. Two divisions, viz., the 5th and the 14th, are at Kalisch and Chenstokow. These are in the neighbourhood of the junction of the Austrian and Prussian frontiers. The 11th, 12th, and 13th divisions are quartered at Doubno, Umane, and Zamosc. These are able to watch the Austrian frontier. Finally, the 7th and 8th have their head-quarters at Elizabethgrad and Kischeneff, in the neighbourhood of the Roumanian and Turkish frontiers.

Thus far I have touched very briefly upon the general nature of the arrangements that continental armies have recently made in the distribution of their cavalry forces, and of the causes that have rendered those arrangements an imperative necessity to them all. In order to give a clearer insight into the subject of my lecture, I now propose to take the cases of the cavalry of two or three of the largest continental Powers, and to show, as far as the limited time at my disposal will allow, what has been done and is doing by each of them to develop the capabilities and to improve the efficiency of this arm. These improvements may, for the sake of clearness and order, be divided under three heads, viz., improvements in organisation, improvements in equipment, and improvements in practical instruction and work.

The Russian Cavalry.

I will first take the cavalry of an army to which much attention is naturally directed at the present time. Every one who knows anything of the history of the Russian army during the last five or six years well know that she has been perhaps more energetic than any of her neighbours in reforming the organisation and developing the capabilities of her numerous cavalry. To the manner in which she has found it advisable to quarter her cavalry in time of peace, I have just referred. But the new organisation which was instituted in 1873–4 embraced an all-important point which had not previously received the attention which it demanded or deserved. I refer to a systematic organisation for providing reserves both of men and horses to fill up vacancies in the ranks, both in peace and in war. This has been effected by organising a certain number of reserve brigades (each consisting of six squadrons) and affiliating one of them to every two divisions of cavalry. These brigades are stationed at such points in the interior of the empire as are deemed convenient and suitable for the supply and training of horses. Another new feature in the organisation of 1874 was the permanent status which was given to the Cossacks and their association with the cavalry of the Line. A corps of these troops now forms one of the permanent units of every division of Russian cavalry of the Line, while forty additional regiments can at once be mobilised on the outbreak of war. The Russian cavalry

has, moreover, been divided under five heads, viz., cuirassiers (who only exist in the guard), dragoons, lancers, hussars, and Don cossacks. Each division of the Line cavalry, which comprises four regiments, is composed of a regiment of each of these troops, viz., one regiment of hussars, one of lancers, one of dragoons, and one of cossacks. Thus it will be seen that these divisions are ever maintained even in time of peace completely organised; while in order to enable them to take the field at any moment, ten or eleven of these divisions are permanently quartered in close proximity to the western frontier of the empire.

With regard to equipment, the rear rank of the Russian lancers and hussars were in 1871 armed with Berdan carbines, while the front rank, in addition of course to the sword or lance, have a revolver of unusual power.

In the matter of training and equipment there is an important point to be noted in the Russian cavalry of to-day. Taught by the useless sacrifices and terrible losses invariably suffered by masses of cavalry in the Franco-German war, whenever it was attempted to use them in the old style against the infantry, and taking advantage of the experiences of the American war, Russia has alone of the great powers of Europe, been wise enough to train a large portion of her cavalry to act avowedly as mounted rifles. The dragoons (of whom there is one regiment in every division), are nothing more nor less than mounted rifles, and receive a special training in order to fulfil the *rôle* of such troops, and thus to develop the capacities of the cavalry arm. The regulations for their instruction prescribe that they are to be specially taught to pride themselves upon their ability to fight on foot, and to take the place of infantry; and it will be interesting to watch in the present campaign on the Danube and in Asia what occasions present themselves for the use of these Russian dragoons, and what services they are able to render to their own side.[1]

The German Cavalry.

Let us now turn to the German cavalry, and let us note (though I fear in a somewhat cursory manner), what they, who generally lead the way in these matters, are doing to develop the capabilities of their horse.

First as to *Organisation*:—

A German cavalry regiment consists of four active and one depôt squadron. On the order, therefore, being received to mobilise, the

[1] With reference to this subject the following extract appeared (since this lecture was given) in a letter of a military correspondent of the *Times*, who was with the Russian army. It relates to the capture of Tirnova by five squadrons of dismounted dragoons :—

"Tirnova, July 8.

"We have taken Tirnova. Only five squadrons were actually engaged, with two "and a half squadrons of cossacks in support. The Turks abandoned an excellent "position, where they had four battalions, amounting to between 2,000 and 3,000 "men, and abandoned, not only their arms and ammunition, but a mass of powder "and cartridges in boxes, retreating in great disorder, pursued by the dragoons on "foot for some miles."

transfer of ineffectives to the depôt and of effectives from the depôt-squadron is easily managed at once. Some fifteen or sixteen horses per squadron also have to be purchased in order to bring up the regiments to their war strength. With a view of obviating any unnecessary delay on this account, an order was issued some three years ago empowering cavalry commanding Officers to make provisional contracts for the immediate supply of these augmentation horses. The result of these and other similar measures is, that the Prussian cavalry can now be mobilised in about half the time required by the other branches of the Army. Consequently it can take the field, can cover the concentration of its own forces, and have done much of the preliminary work that pertains to it on the outbreak of a campaign by the time that its own main army is ready for action. The principle that has enabled this result to be attained is a rigid system of decentralisation, which necessitates, and therefore ensures an equal distribution of work.

I pass on to the subject of equipment. The German cavalry has within the last few years been armed with a new carbine of increased range and power. Two men and one non-commissioned officer per squadron are equipped as pioneers, and have to go through a course of instruction and training with the engineers. In addition to their tools, these men carry with them some preparation of dynamite made up into cartridges, to assist them in any work that they may have to do. Though the general equipment of the German cavalry has its weak points, which are chiefly owing to the rigid economy with which everything is done, yet in everything there is apparent that striking characteristic of the German Army, viz., a willingness to take immense pains beforehand in small and apparently trifling but really important details.

Next as to instruction and practical work.

In this respect the Germans, I think, are not likely to lag behind their neighbours. First and foremost, about four years ago they introduced into their cavalry regulations a detailed chapter of instructions, embodying the admirable principles and maxims for the tactical use and guidance of large masses of cavalry in different lines that were first advocated by the late General von Schmidt, who died two years ago. That the soundness and excellence of these instructions have been generally recognised, is evident enough from the fact that they have been copied and adopted more or less by every army in Europe that has a cavalry worthy of the name. Secondly: the probability that the cavalry soldier will henceforth have to do a good deal of his fighting on foot has not escaped attention. In order to give the cavalry divisions more defensive powers in case they meet with a strong body of the enemy when operating in advance of their own main Army, the men are now practised in infantry drill, and for this purpose an Officer and two non-commissioned Officers have been, since last year, detached from each hussar and dragoon regiment to be attached to an infantry battalion to be trained and instructed in rifle practice and in infantry tactics. Another innovation, dating from last year, may be noticed in the "Kavallerie-ubungsreisen," or cavalry practice rides which

have been specially devised for the training of efficient troop and squadron leaders. To improve these latter in their duties as leaders of scouting and reconnoitring parties, instruction is now given to them in each army corps during a tour made by them, which lasts several weeks under the guidance of experienced cavalry commanders or Officers of the general staff. Again, there is the cavalry school at Hanover, where, in addition to the one-year course of instruction for Officers and non-commissioned Officers, there are during the summer, several fortnightly courses of instruction for practice in destroying railways and telegraphs in a campaign. Other details might be noted, but these for the present must suffice. On the whole it may safely be said that the German cavalry do not mean to let the grass grow under their horses' feet on the outbreak of the next campaign in which they may be called upon to serve.

The Austrian Cavalry.

I will now take a cursory glance at the Austrian cavalry. Though there have been considerable changes of one kind and another made in it during the past few years, there is not much that need be specially noted on the present occasion. As in Prussia, the cavalry is so organised that its mobilisation can be effected, and it can be put into the field sooner than the rest of the Army. It is, moreover, always kept up on a war footing, so that on an outbreak of war the regiments move at once, leaving all the work of mobilisation to the depôts. Since March, 1871, each squadron has been augmented by thirty-one mounted and four dismounted men.

In the matter of improvements and alterations in equipment, &c., the dress of many of the regiments has been changed and rendered more serviceable; five men per squadron, and also the fourth section of every sixth squadron are trained to act as pioneers, and carry, in addition to their arms, the necessary tools for the work which they have to do, whilst a subaltern Officer in every regiment is specially trained to instruct these men. In order to enable the lancer regiments (of which there are now only eleven, instead of thirteen as formerly) to cope with other cavalry on service, thirty-two of them per squadron carry a carbine, while the rest of the men, as also the non-commissioned Officers, carry a revolver of the same bore and ammunition as the carbine with thirty rounds of ammunition, while the carbine men carry fifty-four rounds. Finally, in the matter of instruction a good deal of progress has during recent years been made in the Austrian cavalry. For the instruction of the Officers, not only cavalry but also staff riding excursions are practised from time to time under the immediate superintendence of the chief of the staff, while a scientific reconnaissance takes place by regulation annually in every general command. The instruction of the conscript also in regimental schools has made good progress during late years, and the training imparted to the Officer is by regulation passed on through the non-commissioned Officer to the men, so as to obtain thorough intelligence in scouting and reconnaissance work. In conclusion, it may be remarked that the Austrian cavalry copies the German cavalry in an almost slavish fashion.

The French Cavalry.

The limits of my time and space will hardly permit of my discussing at any length the French cavalry on the present occasion. It must therefore be sufficient to say that since the Franco-German war, great attention has been paid to the cavalry in France. The improvements which have been made in general organisation, in equipment, and in practical instruction and work have nearly all been based upon the German model. As far as I know, however, no new paths of development, special to the French cavalry, have recently been struck out which might call for remark upon the present occasion.

The American Cavalry.

A lecture that aims at dealing with the progress made in developing the capabilities of cavalry during recent years would obviously be defective in a most important point, if reference were not made in it to the cavalry organised by both sides in the American civil war. The shrewd, practical, common sense of the American people, and the utter absence of tradition, prejudice, and red tape led them to adopt a system of tactics somewhat new and peculiar to themselves and not at all in accordance with European notions, practices, and ideas, but one nevertheless wonderfully adapted to their circumstances and to the state of war at the time. At the beginning of the war both sides were totally unprepared for hostilities, and armies had to be organised, drilled, and equipped before operations could be begun. With regard to the cavalry, both sides were at first inclined to act upon the ideas, then very prevalent, of the uselessness of mounted men as against the new infantry firearms, but they soon discovered their mistake, and the mounted service increased rapidly, so much so that at the latter end of the war, the northern states maintained no less than 80,000 cavalry, almost all mounted riflemen. The brilliant and, in some cases, extraordinary services that large bodies of both the Federal and the Southern cavalry, armed and equipped as mounted rifles, performed for their respective sides are matters of history, and certainly serve to show that the contending parties originated and improved a system of working cavalry that was capable, under some conditions, of producing the greatest results. No one can read and follow the accounts of Morgan's raids, of Forrest's expeditions, of Stewart's great sweeping reconnaissances, of Grierson's operations in Mississippi, of Wilson's invading cavalry, of Sheridan's turning movements at Petersburg, of his fighting in line of battle, of his pursuits, &c., &c., without feeling that the mounted rifle principle is capable of being made wonderfully effective, and that it is, in despite of some difficulties and drawbacks, a most advantageous way of employing horsemen in the improved state of projectile weapons. It has always been inexplicable to me why the valuable experiences of the American civil war on this subject were not sooner taken to heart by the great armies of Europe. What has been the actual fact? It is only now after the Franco-German campaign, in which both the French and the German cavalry (both drilled, equipped, and manœuvred in the old fashioned style) utterly failed to

effect anything on any field of battle at all proportionate to the cavalry forces employed or to the sacrifices incurred, that the experiences of the American war are beginning to be acknowledged and to bear some small practical fruit. A more striking instance of utter failure to profit by the experiences of others could scarcely be adduced. Even on reconnaissance duties, as soon as the Franc-tireurs were organised, the training, equipment, and armament of the much-vaunted Prussian Uhlans rendered them quite unable to cope with foes who, though brave, must, from want of training and organisation, have been contemptible in themselves. In order to deal with them, the Prussian cavalry had to arm themselves, as is well known, with chassepôt rifles taken from the enemy, or to be accompanied by infantry to clear the villages of these volunteer riflemen. Now I would ask anyone what was a German cavalry soldier, who was obliged in self-defence to equip himself with a long chassepôt rifle and to carry it about with him on horseback, but a mounted rifleman? He was, however, one of the worst and most awkward kind, because he was improvised suddenly, and neither his training nor equipment were adapted for the new *rôle* which he found himself, *nolens volens*, called upon to play.

In America, on the other hand, the cavalry acting as mounted riflemen were, as pointed out by Colonel Denison in his recently published work, "The History of Cavalry," continually taking towns and villages, which were well defended in many instances by infantry and artillery. In America, the Home Guards, which on the Federal side represented the same type of force as the Franc-tireurs in France, never checked the onward and rapid progress of the Southern Horse. As to the latter being accompanied by infantry, they would have laughed to scorn the idea of being thus hampered or delayed in a raid or partisan operation.

With regard to the armament used by the American cavalry or mounted rifles, the experiences of the American war clearly brought out two important facts, viz., the deadly efficacy of the revolver, both as a defensive and offensive weapon in the hands of a cavalry soldier and the total inability of the sabre to hold its own against it. This, of course (though it is generally deemed rank heresy to say so) was well known long ago to those who have seen any actual hand to hand fighting; but it is strange that so noteworthy a fact as this should, in the training and equipment of all European cavalry, till the last two or three years, have been resolutely ignored. For full information, however, upon this subject I must refer my audience to Colonel Denison's lately published work, in which the whole subject will be found fully discussed.

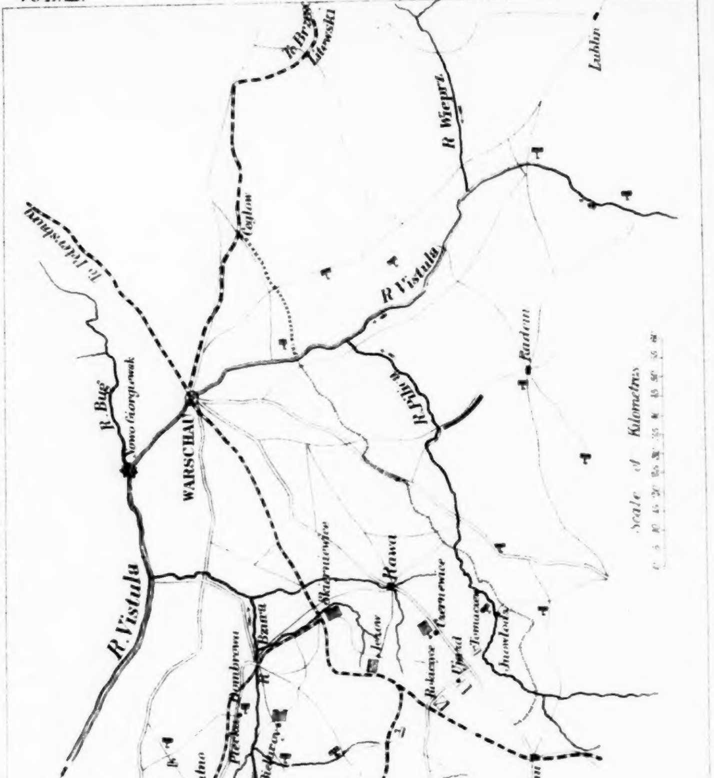
Manœuvres.

There is another great means of instruction and practice open to the cavalry forces of Europe which I have hitherto not touched upon; I refer, of course, to cavalry manœuvres, which in all Continental armies, as well as in our own, have been a recognised institution for some years past. Not an autumn now passes without large bodies of cavalry being assembled in various parts of Europe for the ostensible

purpose of practical instruction and exercise of this arm in the various duties that in future campaigns will fall to its lot. Now of course these cavalry manœuvres, like those of any other troops, are only useful and instructive to those who take part in them, just in proportion as, in spite of all hindrances and restrictions, they convey a fair but necessarily somewhat faint representation of some of the duties which, in an actual campaign, would have to be done. In other words, the more, what may perhaps be termed the indispensable element of "make believe," can be eliminated or kept in the background, the more benefit are the troops likely to derive from them.

Now, both in continental armies and in our own, the endeavours that have been made to give these cavalry manœuvres, or rather the practical instruction of large bodies of cavalry, much *vraisemblance* to real campaigning have been cramped by sundry difficulties and restrictions, and therefore have not, as is now generally acknowledged, been attended with much success. The reasons why this has been so, are plain and obvious enough. Both at our own and also at continental manœuvres, large bodies of cavalry are nearly invariably employed in one of two ways; they are either exercised in conjunction with a considerable force of all arms, or they are assembled by themselves for manœuvre with their due proportion of horse artillery attached. In the former case, whenever there is a field-day and two forces oppose each other with some prescribed plan or general idea, the bulk of the cavalry belonging to each force is naturally employed in reconnoitring in front of the main body, in order to watch and give notice of the approach of the enemy. Unfortunately, however, even under the most favourable circumstances the two opposing forces are at starting never much more than five or six miles apart. Hence it almost invariably happens that as soon as the cavalry of each side have traversed some two and a half to three miles or so, they meet each other, and after skirmishing or holding each other in check for about half an hour or more, the infantry and artillery of both sides come up, and the cavalry have to get out of the way and out of sight as quickly as possible, lest they be put out of action, and nine times out ten they might just as well go home at once as be kept hanging about, as they usually are, on the outskirts of the action that ensues. I appeal to any one who has taken part in, or who has witnessed these sort of field-days, not only at Aldershot (for, as far as I have seen, I think we play the game quite as well as our neighbours), but anywhere on the Continent, as to whether this is not a fair representation of what, on these occasions, usually takes place. In such cases as these, the practical instruction of the cavalry falls far short of its mark, because there is lacking the one primary essential for giving useful instruction to that arm in considerable bodies, viz., a zone of operations of sufficient depth for the practice of the various duties that it is desirable that they should learn. So much for one of the ways in which cavalry is used at manœuvres. With regard to the other plan generally adopted, viz., the assemblage of brigades and divisions by themselves, with a due proportion of horse artillery attached, it may be remarked that on such occasions, perhaps even more so on the Con-

tinent than with us, the cavalry is employed in tactical exercises and evolutions, having for their object the practice of fighting in large masses The instructions contained in the now well-known Section V of the Prussian cavalry regulations may be taken to illustrate the manner in which on these occasions large bodies of cavalry are employed. But even when (and I speak both of manœuvres on the Continent and also at home) on these occasions the available cavalry force is divided, and one half of it operates against the other half, some of the causes to which I have already referred, mar the usefulness of the exercises, and cause them to fall far short of what might be made of them. The area of operations is so restricted that the two opposing forces seldom are separated by more than a very few miles from each other at the start. Too often, indeed, they start from the same barracks or camp, one side an hour or so after the other, and in the generality of cases the zone of operations and the ground generally is perfectly well known to both sides. These shortcomings and defects in the instruction of cavalry have been perceived on the Continent quite as much as with us, and for several years past it has been more or less generally felt that cavalry manœuvres, as at present conducted, are deficient in usefulness, and that they convey to the great mass of those who take part in them but a very faint representation of the difficulties and nature of the manifold duties which a cavalry force, acting in front of a main army, would have to perform. It is seen, moreover, that they afford but small scope and opportunity to the great mass of subordinate officers, *i.e.*, leaders of troops and squadrons, upon whose skill and judgment so much must in future campaigns often depend, to practise on any *extended scale* the various duties of their craft. Verdy du Vernois, besides other German writers and critics of less repute than he, has not failed to point out and to comment on these shortcomings in the training of the German cavalry; and it was owing evidently to a perception of them by the German military authorities that the cavalry "practice rides," to which I have already referred, were last year introduced into the German cavalry. These cavalry rides were specially devised to meet the deficiencies of instruction upon which I have just commented, inasmuch as it was officially prescribed at the time of their introduction that they were intended for the training of subalterns and captains of cavalry. These Kavallerie-ubungsreisen, I would remark by the way, are not to be confounded with the "generalstabsreisen," which are institutions of a much older date. The introduction of these "cavalry practice rides" was doubtless a step in advance. It has, however, been already felt that, although very well in their way, these "rides" cannot wholly make good the deficiencies which they were meant to remedy. They possess, of course, one inevitable defect, viz., that the troops on both sides are purely imaginary, and that, therefore, even under the most able and practical leadership, they, even more than ordinary cavalry manœuvres, are necessarily lacking in any *vraisemblance* to real campaigning. Hence, as owned by the Germans themselves, their value is, after all, but of a very limited kind. Last autumn, however, another great step was made towards developing and improving at annual manœuvres


WARSCHAU
R. Vistula
R. Bug
Nowo Georgiewsk
To Petersburg
R. Wieprz
Lublin
Radom
R. Pilica
Rawa
Skierniewice
Bzura
Kutno
From Thorn
R. Nerfluss
R. Wartha
Kalisz
R. Prosna
Petrikau
P O S E N
Western Cavalry
Eastern Cavalry
Movements of Flying Column
Do. Do. after 17th Sept.
Principal Roads to frontier of Posen on Warsaw
Other Roads
Railways
Scale of Kilometres

J. Jobbins

the practice by cavalry of the duties which would, in real warfare, often fall to its lot. This time, however, it was not the Germans, but the Russians, who led the way. The Russian military authorities decided to give to two large opposing bodies of cavalry a zone of operations amply sufficient, both in depth and width of front, to afford full scope for reconnoitring skill, for secresy, for rapidity, and for marching powers, and upon the leaders of each side was imposed a task precisely similar to that which the cavalry of any great Power might, in the event of an outbreak of war with any of its neighbours, have to perform. I propose to dwell, in some little detail, upon these doings of the Russian cavalry last year, and that for several reasons, which may be enumerated as follows:—

1stly. They form the first instance in Europe where a large cavalry force engaged in manœuvres has attempted to undertake a "raid," after the American fashion, against a far distant point of the enemy's communications.

2ndly. The area or zone over which the operations extended was both in depth and breadth of front an unusually large one, and therefore amply sufficient to afford full scope for the display of strategic skill and ability on both sides.

3rdly. An entirely new feature was introduced on this occasion, in order to aid the troops and to give the whole affair as much resemblance as possible to real warfare, viz., the co-operation of the whole of the civil and local officials on both sides.

I will now, therefore, endeavour, by giving a brief summary of the doings of the Russian cavalry in the autumn of 1876, to convey to you some idea of the nature and extent of the operations then carried out.

Scene of Action.—The scene of action lay between the Upper Varta, and to the east as far as the Vistula above Warsaw, *i.e.*, as far as the line of railway connecting Warsaw with the fortress of Brecz Litewsk.

The design of the manœuvres was to give the cavalry an insight into some of those strategical exercises which, on a declaration of war, might specially devolve upon the cavalry of any continental Power. These exercises embraced:—

I. Hindering and checking the mobilisation of isolated portions of the enemy's army. II. Acquiring possession of the lines of railway important to the enemy, also of positions for the purpose of harassing the enemy, or those likely to prove advantageous to their own army. III. Covering mobilisation and protecting lines of railway against the attack of the opposing cavalry. IV. Reconnaissance of large tracts of country and of special localities, acquiring intelligence as to the enemy's numbers and general strength, besides the performance of outpost duties. The two opposing forces may, for convenience sake, be termed the Western and Eastern corps; the Western corps (which was the cavalry of invasion) comprised 33 squadrons with 24 guns. The Eastern corps, whose business it was to defend a certain line of frontier, and to defeat the projects of their opponents, numbered 40 squadrons with 30 guns. In addition to the cavalry, the troops that were garrisoned within the district chosen for the manœuvres, took

part in them. These comprised 33 battalions of rifles, five infantry regiments, and six batteries of foot artillery. The garrisons lying within the area traversed or occupied by the advancing troops, were considered as included in the mobilisation. These troops had to oppose obstacles as far as possible in the way of the pursuing cavalry, not omitting to protect their garrisons from surprise. These latter were, however, supposed to be chiefly engaged in completing their mobilisation, and were not to oppose the advancing cavalry at more than half-a-day's march from their cantonments.

The "general idea" was as follows:—A Western Army operating from Posen on Warsaw has, on the declaration of war, pushed on its cavalry (cavalry of invasion) on the two main roads leading from the Grand Duchy of Posen on Warsaw, having actually established one division on the road near Kutno and Leczyca, the other southwards above Petrikan. At the beginning of the advance, the Southern division of the cavalry of invasion was to send out a detachment to menace the point of union of Warsaw's railway communication lying beyond the Vistula with the fortress of Brecz Litewsk. At the moment of the irruption of the cavalry invasion, the troops of the Government of Warsaw were supposed to have only partially effected their mobilisation, the cavalry (of the Eastern corps) finding itself with one division and the brigade of guards in and near Warsaw, one division being on the point of advancing from Lublin on Radom, south of Warsaw. It devolved upon the cavalry of the Eastern corps to meet the enemy with the forces at its disposal, to guard the important railway junction at Skierniewicz, and to protect the railway communication in rear, *i.e.*, to the east of Warsaw. Very explicit orders were issued by the commander of the Eastern corps to the garrisons included in the mobilisation, which lay in the scope of the operations of the invading cavalry. In order to render the general arrangements more perfect and thorough, all the civil and local authorities throughout the extensive zone of operations received the most stringent orders to give every assistance that lay in their power to the sides which they were respectively directed to take. Nor were these directions merely general ones. These local authorities received from both the head-quarter staffs the most detailed and careful instructions, pointing out to them the system they were to follow in order to keep themselves *au courant* with the movements and the advance of the enemy; the postal and telegraphic lines by which these reports were to be forwarded to certain points, how they were to act on certain contingencies, &c., with all other necessary details.

It would obviously be impossible within the limits of a lecture like the present to follow closely and in detail the course of the operations; I must, therefore, content myself with briefly giving the general result of them. The invading cavalry succeeded in overcoming or passing by with ease the various infantry garrisons lying within the scope of their operations, and thus rendered the mobilisation in that quarter futile. This easily attained success was due, however, rather to a want of proper precaution on the other side than to the actual conduct of the operations of invasion.

The first conflict of large masses took place in the vicinity of the great railway junction of Skierniewicz, where the invading cavalry gained a decisive victory, chiefly because the leader of the opposing troops was so placed that he could not combine the offensive—without which cavalry cannot hope for success—with the defensive; and also because he did not know how best to avail himself of a partial success over the enemy. It is very interesting to follow the movements of a flying column, composed of four squadrons of the division of the invading cavalry, advancing over Petrikan, which was despatched across the Vistula in order to destroy the railway communication between Warsaw and Brecz Litewsk. In order to estimate the nature of the task allotted to this corps at its just value, it must be observed that between Petrikan, the starting-point of the movements of this column, and the railway junction above named, lay no less than 300 kilometres; that, besides a broad river, several tributaries had to be crossed, and that the force succeeded not only in misleading the opposing troops as to its intentions, but also deceived the civilian auxiliaries, whose duty it was to communiciate to the officer commanding the Eastern corps every movement of his opponents. It was a task as difficult as any undertaken by the most daring leader in the cavalry raids in the war of the American secession. To detail the circumstances briefly, the corps in question, carrying with it on pack horses the necessary provisions, started from Petrikan at 10 a.m. on September 15, crossed the Piliza twice, and on September 17, at 6 A.M., reached the banks of the Vistula, having cleverly deceived its opponents as to its line of march. On the first day, the force had covered 40 kilometres; on the second, excepting a halt of two hours' duration, it was on the march day and night, not halting until 6 A.M. on the third day. Thus in forty-eight hours, 160 kilometres were accomplished, one squadron of hussars actually marching 180, small advanced guards and patrols completing 200. The march was partly across country over heavy ground: on the second day the weather was very severe. The great rapidity of the movement of this body of troops caused all the measures adopted by the enemy on information received relative to its whereabouts, to be behindhand.

During the whole of the 17th of September the passage of this party over a ford took place without any serious inconvenience from the enemy. It seems inexplicable, as such an attempt on the part of the invaders was expected, that the ford was not held on the further bank. A proper occupation of this portion, and decisive measures along the whole length of the threatened portion of the stream would have rendered any crossing impossible for the invaders. Further, after the column had successfully gained the further shore, it remained only 7 miles from the line of rails to be destroyed till the 19th September; thus two full days were lost in inactivity after the first stage of the fording had commenced. Not till the end of this period did the commander proceed to the completion of his task which, notwithstanding the loss of time, thanks to the want of energy on the part of his opponent, he accomplished. The delay after the passage of the Vistula cannot be regarded as a voluntary one, as the least

display of energy on the part of the opposing force would have resulted in the overthrow of the whole undertaking, besides seriously endangering the corps engaged. The rest which the corps allowed itself in this trying situation, notwithstanding the contrary assertions of the *Russian Invalide*, is only to be explained by the reflection that after the forced march of the preceding days the troops were in urgent need of repose and refreshment before undertaking further operations.

The cursory sketch that I have here given is an attempt to describe the latest, and, I think, the best effort that has been made during recent years by any cavalry in Europe to develop at peace manœuvres the capabilities of that arm, and to afford it an opportunity of rehearsing the self-same duties that it might oftentimes, on an actual declaration of war against a neighbouring state, have to perform. No one who has read the Russian official accounts of the operations, and also the comments upon them, in the French and German military organs, can fail to be struck with the immense pains that were taken to give the whole affair in every particular as great a *vraisemblance* as possible to the real thing.

Naturally, this whole subject has attracted much attention, and given rise to a good deal of discussion both in Germany and in France. Military critics of the former country speak highly of the utility of such exercises, and own that the Russian cavalry has in this made a considerable step in advance of their own horse. So much, indeed, are they impressed by this that already I perceive that detailed and well-considered plans are being put forward and discussed for the execution of similar manœuvres by the German cavalry in the coming autumn.

Our own Cavalry.

A lecture upon this subject and in this place would naturally be felt to be somewhat wanting in practical utility and application if reference were not made in it to our own cavalry, and to the progress that we have (or ought to have) been making towards developing to the utmost its capabilities of action in future warfare. I propose, therefore, before concluding, to make a cursory examination of what we have done during recent years, and what we have left undone.

First with regard to organisation. I fear that in this respect we can scarcely claim to have made any progress at all, inasmuch as there have long existed several patent defects in the organisation of our cavalry which would go far to cripple its efficiency in a campaign. These defects are the more vital, inasmuch as organisation must precede action, and all theories and practical instruction are useless, unless the power exists to give them practical application in war. These shortcomings have been so long known and recognised that I will refer to them very briefly now. First and foremost is the very weak numerical strength of many of our regiments. Take, for instance, a light cavalry brigade, consisting of three regiments of hussars. Each of these corps has an establishment of 320 horses. If we deduct untrained remounts and inevitable casualties, no hussar regiment on the

home establishment conld put more than 270 horses in the field. Hence, a British light cavalry brigade does not comprise more than 800 effective horses, even at the outset of a campaign. This is rather less than half the effective strength in horses of a continental, *i.e.*, of a French, Austrian, or Prussian brigade. Take again the case of a heavy cavalry brigade, such as, for instance, the Household Brigade. These regiments have only 275 horses. If, therefore, they were ordered on service at any time, all the three regiments together could not put much more than 700 horses into the field. If we had any reserves, either of men or horses, this small numerical strength would not be of so much moment, but it is another great element of weakness in our organisation that we have no reserves of either, nor does there appear to be any prospect of our ever having any. Consequently, it is perfectly well known that if half-a dozen cavalry regiments had to leave England with an expeditionary force at any time, they could only be made up to their very weak established strength by wholesale borrowing, at any rate of horses, from other corps. With regard to any measures of decentralisation which might have for their object to enable a cavalry brigade or regiment to take the field, or to be ready for embarkation without much preliminary notice, &c., &c., nothing has ever been attempted. Another recognised defect in our organisation is that we still maintain the troop as our administrative, and the squadron as our tactical unit. The absurdity and disadvantages of maintaining these two differing units are so well known, and have been so often pointed out, that it is needless to dwell upon so threadbare a topic. On the whole it may be said that, as regards organisation, our cavalry is just where it was a quarter of a century ago, that it is not organised for war, and that it would be impossible for our cavalry regiments long to sustain the stress that war would throw upon them.

Equipment.—With regard to equipment, I do not know that there is very much to be said. In perfection of turn out, in general appearance, in *physique*, both of men and horses, we can hold our own anywhere, and are far better than nine-tenths of our neighbours. But what improvements in equipment have we made with the view of developing our capabilities in the next campaign in which we may have to fight? We have certainly as good a saddle as our neighbours, and I think that if Captain Crichton's saddle be adopted, we shall have a better one than any of them. In a short time we shall have a carbine of increased power and range (I refer to the Henry-Martini); and last, but not least, it is, I believe, intended to arm our fine lancer regiments with carbines. This latter is certainly a step in the right direction, which has already been too long delayed. On the other hand, we have not succeeded, any more than our continental neighbours, in reducing the weight on the horses' backs. None of our men are equipped or trained to act as pioneers, and we should, therefore, on a campaign, be still dependent upon the engineers for the performance of those duties which, in most continental armies, cavalry pioneers are now trained to perform. With regard to lancer regiments, the present tendency seems to be to give them, in so far as their firearm is concerned, a mixed armament. For instance, in the Austrian, Russian, and I be-

lieve also in the French army, the men in lancer regiments who are not provided with carbines, are armed with revolvers. Provided that the ammunition for the two weapons is the same (as it is in the Austrian cavalry,) this is a wise arrangement, inasmuch as it gives a regiment a great increase of offensive power In a close *mêlée*, where horses and men are generally jammed together, and half the men have not room to use either their lances or their swords, the experiences of the American war show clearly enough that the revolver can be used with far more deadly effect.

There remains the question of what improvements we have made in practical instruction and work. Here I think that we may be said to have made some real and substantial progress. Our drill has been reformed and simplified in many respects, the regulations for our various exercises and training have been brought more into harmony with the requirements of modern fighting, and a systematic course of instruction in the practical duties of cavalry has been set on foot, which wherever it is conscientiously carried out, cannot fail to produce excellent results. The musketry regulations for cavalry have, moreover, been modified and altered so as to afford the men better practice for dismounted work.

Our own Cavalry Manœuvres.—And now a few words with regard to our own cavalry manœuvres, or summer drills. I have already referred to and commented upon the causes that tend to make these annual exercises both here in England, and also on the Continent, fall far short of the practical teaching that they might, under other and more favourable conditions, be made to impart. But in England, more than anywhere else, it is of course especially difficult to give our cavalry much practice that will really be useful to them in future campaigns. Owing to the great respect for private property that everywhere prevails with us, the troops are hampered by many very necessary rules, conditions, restrictions of space and ground, and other difficulties with which Continental troops have not, as a rule, to contend, or which oftentimes exist for them in a far less degree than for us. It is of course easy enough in a despotically ruled country to devise and carry out manœuvres on the system and principles that were followed in Russian Poland last year. There the Czar has only to say, "Sic volo sic jubeo," and all officials, both military and civil, hasten to obey his behests. Even in most other countries of Europe, where the government is accustomed to carry things with a tolerably high hand, there would be considerable friction and difficulty to be overcome before arrangements could be made to give the instruction and practice of large bodies of cavalry so complete a *vraisemblance* to real service as in those which took place last year in Russian Poland. With us in England, any such arrangements would of course be quite out of the question. It is plain, therefore, that we must limit our aspirations to what is possible. But that it is possible, hampered though we are, to get more profit and practical instruction out of our manœuvres than we generally do, I think that no one who has considered the subject can doubt. For instance, it is hard to see why, on the rare occasions when there are a couple of cavalry brigades

available to operate against each other, there should not be found for them a zone of operations sufficient in depth and width of front to give them plenty of real practice in the many difficult duties which in actual warfare they would have to perform; in other words, why, instead of operating over some four or five miles of perfectly well known ground, should not the two brigades be encamped at least some 15 or 20 miles apart? A general idea might then be devised, the working out of which would necessitate working over comparatively new and unknown ground. Of one thing I am certain, viz., that the greater the *vraisemblance* and appearance of reality that is given to our cavalry manœuvres and to the manner of carrying them out, the more interest and zeal will all, from the highest to the lowest, take in the due execution of any work they may be instructed to carry out.

Conclusion.

A few words more and I have done. After passing in review as I have attempted to do what the cavalry of some of the principal armies of Europe have been doing to develop their capabilities in future warfare, it is well to ask ourselves what are the conclusions we may draw from all the care and elaborate instruction that is now bestowed upon this arm? Of course there are some which are apparent enough and well known to everybody. But there seem to me to be one or two conclusions to be drawn, which have not I think, among ourselves at any rate, met with the full and frank recognition that they deserve. The first of these is that in future the cavalry soldier must be very much of a hybrid animal, and must be trained and able to do a great deal of his fighting on foot and to do it well. We may not like this idea; on the contrary, we may resent it as being opposed to our prejudices, traditions, and ideas; we may ignore it theoretically in our regulations or only faintly acknowledge it; but, in spite of all that, the signs of it are everywhere apparent. They may be seen in the great results that the Americans, in their great civil war, attained with their cavalry, who were equipped and used as mounted rifles. They may be seen in the fact that the Russians, in addition to teaching all their cavalry to fight more or less on foot, have one regiment of each cavalry division (viz., their dragoons) equipped and trained as mounted rifles. The signs of it may be seen in the more copious instruction that in all the revised cavalry regulations of foreign armies and in our own, is given to dismounted service, and in the fact that in most of the great armies of Europe, the cavalry has within the last year or two received long-range carbines of increased range and power to be used solely on foot, while we ourselves are about to exchange the Snider carbine, which has a range of only about six hundred yards, for the Henry-Martini, which, though a somewhat heavier weapon, is sighted up to a thousand.

But in addition to this increased prominence and importance that will henceforward be given to the firearm of the cavalry soldier, I am afraid that yet another good old tradition and idea that during many generations of cavalry soldiers has been fondly cherished, and that has

done good service in its day, must perish also, viz., that the sword and lance are the primary weapons upon which the cavalry soldier when mounted should rely. We have gone on repeating this so long, we have ever had it so impressed upon us since the days of Frederic the Great, that cavalry relying in any degree on firearms are necessarily worthless, that however doubtful some of us may have been as to whether such maxims and principles as these may not have belonged to a bygone time, we are most of us more or less unwilling to discard the idea, and doubtless, in the opinion of many even now, it will be deemed rank heresy to question it. But nowadays it is no longer any good to shut our eyes to the fact that in many positions in which cavalry may be placed, such time-honoured rules will only hold good as long as your enemy will consent not to use his firearms! The fact is, that the invention of the revolver has given the cavalry arm an improved weapon quite as advanced in proportion to the old horse-pistol as the breachloader is to the old musket. At close quarters the revolver is one of the most deadly weapons ever invented. What, it may be asked, would be likely to be the result of a contest between two tolerably matched opposing bodies of cavalry, the one side relying upon the sabre and lance, and the other side making use of their revolvers whenever they had a chance of doing so. Anyone who has had experience of hand-to-hand fighting will acknowledge that such a contest would speedily be decided in favour of the latter side. Again, in a pursuit directed against either cavalry, infantry, or artillery, a body of cavalry will do ten times the execution if they are armed with revolvers and freely use them, than if they rely only upon their sabres. The experiences of the American civil war, which is the only campaign in which large bodies of cavalry were armed with revolvers and always freely used them in preference to the sabre or lance are, as I think all who read Colonel Denison's remarks on this subject will agree, conclusive. With reference to the contempt in which, during the American civil war, the sword speedily came to be held on both sides, the same author remarks: "Instances can be found without number of cavalry who "would rather themselves rely upon their firearms than their sabres, "but there is no war recorded in history in which the charge hand-in-"hand at speed did not exert a great moral influence upon the enemy "till we reach the novel experiences of the American civil war. The "real truth is that the sabre, as used by European cavalry, is most "harmless as an offensive weapon. The Franco-German war, how-"ever, furnishes a most extraordinary proof of its inefficiency in "this respect. The German medical staff have lately issued a re-"port upon the deaths and wounds inflicted by the various weapons "upon the German troops. The losses of the Germans in the "whole war of 1870–71 amounted to a total of 65,160 killed and "wounded. Of these 218 only were killed and wounded by the sabre "and clubbed muskets. Unfortunately the sabre wounds are not "given separately; but assuming that these casualties were all in-"flicted by the sabre, the result is still most remarkable. Of the "cavalry, 138 were killed and wounded by the sabre out of a total "of 2,236. The most striking point of all, however, is the very small

"proportion of the killed to the wounded. The total killed by the "sabre being, all told, only six! the wounded 212. In all the cavalry "fighting at Woerth, at Vionville, at Sedan, in the battles on the Loire, "and in the northern provinces, in all the outpost service, extending "over almost half of France, the only deaths caused by 40,000 cavalry "with the sabre in six months' campaigning amounted to six, while in "the instances we have just mentioned, out of 100 men, Mosby's "cavalry in one skirmish killed 24 and wounded 12 with their re-"volvers, and in another instance out of a similar number 26 were "killed and wounded in the same way!"

If with such facts and experiences as these to guide us (which have all been gained at the cost and expense of our neighbours) the English cavalry ever finds itself unable to meet its enemy on equal terms, its discomfiture will be due to a protracted adherence to obsolete traditions and ideas and from having turned a deaf ear to the inexorable logic of facts.

The CHAIRMAN: The subjects which Captain Trench has entered into, connected with cavalry and war generally, are so interesting that I hope there are many gentlemen here who will be kind enough to give us their opinions in opposition to, or in elucidation of Captain Trench's ideas, or on the general subject of the employment of cavalry in a campaign.

Lieut. CHAMPION, R.M.L.I.: The lecturer remarked that an improvement had been made by arming the cavalry with the Martini-Henry rifle. Now, Sir, while I quite agree with the gallant Officer that the cavalry should be armed with an effective weapon, and should be so trained as to be worked most effectively on foot, I do not consider that a right step has been taken in arming that branch with the Martini-Henry carbine. It is an effective weapon undoubtedly in the hands of an infantry soldier, but if you want to make your cavalry felt in the performance of the important duties assigned to it in modern warfare, you must arm it with a *magazine* rifle, a weapon that can render the cavalry soldier ten times more formidable than an infantry soldier *for the time being* who is armed with the single-loading rifle. The question of magazine arms has not been sufficiently considered in the British Service; there have been one or two patterns submitted, it is true, but they have not been considered as sufficiently complete to suit the cavalry and artillery branches of the Service. In opposition to this, although the magazine arm is yet, I allow, in its infancy, I take the liberty of asserting that for cavalry and artillery purposes, with all its imperfections, there is not a weapon in existence that can touch it. A body of cavalry making a dash at a battery of guns or a position, can render itself equal to a much greater force of infantry for the time being, because in a magazine arm (for instance, the Winchester repeater), you carry 12 rounds in the magazine barrel, and the beauty of the weapon is, that you can load and fire singly at long distances without touching your magazine at all, and the moment you rush to close quarters you can increase the effect of fire as a cavalry soldier by nearly ten times, without loss of time for loading. The Martini-Henry rifle is a weapon I have a great respect for, having been acquainted with it for three years, and respectable work I have got out of it, but I know that when we do adopt a weapon, we shall be a long time changing for a better and more effective one, and as usual, shall be behind-hand. When the question of arming the cavalry was taken into consideration, the single-loading Martini-Henry should certainly not (in my opinion) have been selected, but it should have been a magazine arm, and, as I have suggested, the Winchester repeater.[1]

[1] Since the above remarks, it appears from reports that the Circassian cavalry of the Turkish Army in Bulgaria has been rendered more formidable and effective than the Cossacks by the arming of the former with the Winchester repeater. In the *Daily Telegraph* it runs thus:—

"The Bashi-Bazouks and Circassians throw the renown of the Cossacks into the

Colonel FLETCHER, C.M.G.: As no cavalry Officer has risen to address the meeting, I wish to ask a question, as an infantry Officer, knowing very little about the subject, on an important point which Captain Trench has brought forward, namely, the desirability of the greater use of the revolver for cavalry on horseback, and what is considered to be the best weapon that could be in the hands of cavalry for use on foot. With regard to what has just been said respecting magazine arms, I am in a position to say that several magazine arms were brought before the Small Arms Committee, one of which was the Winchester. The objection to magazine arms is that they are of great weight, particularly if loaded. The ammunition is carried in the arm instead of in the pouch; and I conclude that as cavalry would almost invariably use the arm when dismounted, they may as well carry their ammunition in the pouch as in the arm itself. If cavalry should fire their carbines from horseback, a repeating arm might be a good one. But this again opens the question whether men ought ever to fire from horseback. Another point on which we want information is the practice that Colonel Denison advocates very strongly—the employment of firearms by cavalry instead of lances or swords. I know Colonel Denison as a practical man, and attach some weight to his authority; but still many of us would be very glad if we could hear the opinions of experienced cavalry Officers as to the views he has advocated. Colonel Denison has been brought in contact with American Officers, and I quite agree that the American war has not received the attention in Europe which it deserves. I think I may say that the opinions stated are so novel that it is necessary that they should be very carefully criticised, and I venture to ask for the opinions of any cavalry Officers here on that particular point.

Dr. CADDY: With regard to the magazine rifle, I think the fusion of the magazine rifle with the Martini-Henry would produce the best possible weapon. The magazine weapon is the best you can possibly have as regards rapidity of fire; but when you come to the Martini-Henry you get penetration, and the penetration of that weapon is one-third greater than that of the Snider. With reference to the merits of the American cavalry, I had an opportunity in 1863 of seeing a few of them at Fortress Monroe, and nothing struck me more than the lightness of the Mexican saddle used by them. It was lined with skins, and they could go on day after day without galling the horses. Of course they had the deadly revolver; but they told me that the revolver is not fitted to stop the go of a horse; it is merely fitted for a man; and that if you come to take to the very large heavy cavalry pistol there are many men who will complain of its weight. Besides that, firing it will cause a serious concussion of the hand and wrist, and many men would be found to break down on that account. A cavalry man must be efficient in his right arm. This question of concussion is very much affected by another question, namely, that of climate. It has been my lot two or three times to witness the effects of severe concussions of the bony system in tropical climates, and they are very much more serious than in a temperate zone. This will have some bearing upon the use of the Martini-Henry. Some years ago, when our Officers were cricketing, I took up a cricketer's glove and put it on my hand, and then dashed it against a post with half strength, but found no concussion of the wrist. I then dashed it at full strength, but still there was no concussion. On the other hand, when in my younger days I put on the boxing-gloves, I found on striking the blow that a severe concussion took place between the wrist and the shoulder. The difference between the two gloves lay in the use of the rubber. I am quite sure that the experience of the great American war has a most practical bearing on the future of our cavalry, especially in tropical climates.

The CHAIRMAN: The subject is both extensive and difficult, and possibly those who have had great experience of independent cavalry work are rather loth to commit themselves to positive opinions on the subject. There is no doubt that much that has been written in the lecture is more fitted for consideration in private than for discussion in a public assembly. Perhaps Captain Trench will be good enough to reply to the observations that have been made.

" shade by their vigorous pursuit; and the Winchester repeating carbine has proved
" itself to be a most formidable weapon."

Captain TRENCH: I am not sufficiently versed in the comparative technical merits of the Martini-Henry, the Snider, and other rifles, to decide which is the best weapon; I merely go upon the broad fact that there has been a Small Arms Committee, who have taken an immense deal of pains with the question, and I assume, therefore, the Martini-Henry is as good a weapon as can be found. With regard to Mr. Champion's observations as to the Winchester rifle, you want a weapon to fire on foot; there is therefore no great object in having a repeating weapon, and I think that nobody proposes that the cavalry should use their carbines from horseback. Our rifles are now delicate weapons; they are sighted for long distances; they require a man to be steady on foot to use them. As you do not use the carbine on horseback, I submit the revolver serves the purpose equally well. There is another objection to the Winchester rifle, namely, its great weight. Some people think a pound or two, more or less, does not matter with a cavalry soldier. The Martini-Henry carbine is exactly a pound heavier than the Snider. That is a drawback in itself, but in this instance it is counterbalanced by the increased range; but if a cavalry man is to carry a Winchester carbine, it would be well to know what the weight is; and if, as I think is the case, it is found to be half a dozen pounds heavier, I think that is a fatal objection. With regard to Dr. Caddy's remarks, as to the great concussion of the heavy American cavalry pistol, that is a matter well worth considering, and I confess it had not occurred to me that there might be too great concussion in firing it. But surely Englishmen have as good wrists and nerves as Americans? If the Amercians could use them throughout a civil war, extending over four years, and in which there were 80,000 men engaged on one side, I cannot see why Englishmen should not do the same thing; but it may be a point worth considering.

The CHAIRMAN: I think there is one point in which we may all agree, viz., in thanking Captain Trench for the lecture he has given us. The points to which he has referred are very important, but possibly they may be better thought of at home than discussed here at present. In your name I beg to return him our sincere thanks.

ERRATA.

No. XCI, on page 734, last line, and on page 735, line 32, for "steam-launch class" read "Staunch class;" and on pages 867—880 (heading to pages) for "Administration of the French Army" read "Administration of the French Navy."

NAMES OF MEMBERS who joined the Institution between the 1st and 15th January (inclusive) and the 13th February and the 13th September, 1877.[1]

LIFE.

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Wisden, T. F., Major Royal Surrey Mil.
Babbage, Henry P., Maj.-Gen., unatt.
Sprot, Alexander, Lieut. 6th Drag. Gds.
Graham, Andrew, M.D., Fleet Surg.
Davison, Thomas, Capt. 16th Lancers.
Massy, W. G. D., Col. 5th Royal Irish Lancers.
Mercer, C. H. L., Lieut. R.A.
Roberts, C. J. Cramer, Major 9th Regt.
Moncrieffe, Robert D., Lieut. Scots Guards.
Webbe, George A., Lieut. 15th Hussars.
Jones, F. Thomas, Major, late 3rd Buffs.
Crutchley, Charles, Lieut. Scots Guards.
Rawson, Harry H., Commander R.N.
Cronin, Alfred C., Capt. 37th Middlesex Royal Volunteers.
Cowley, Norman, Lieut., late 5th Drag. Guards.
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Deeds, W. H., Capt. Rifle Brigade.
Vincent, Edgar, Lieut. Royal Berks Militia.
Wrottesley, A. E., Lieut. R.E.

ANNUAL.

Cox, H. J. W., Capt. 9th Kent Artillery Volunteers.
Eardley-Wilmot, S. M., Lieut. R.N.
Clarke, T. S., Lieut. 60th Royal Rifles.
Brunker, H. M. E., Lieut. 26th Regt.
Healy, R. C., Capt., Assist. Commissary-General.
Purdon, H. G., Lieut. 64th Regt.
Gore-Browne, Harold, Lieut. 60th Royal Rifles.
Campbell, W. P., Lieut. 60th Royal Rifles.
Greaves, George H., Capt. and Adjt. 64th Lancashire Rifle Volunteers.
Cherry, Apsley, Major 90th Regt.
Symonds, R. J., Lieut. R.N.
Watson, H. J., Lieut. 1st King's Drag. Guards.
Berry, George F., Lieut.-Col. 56th Regt.
Underwood, A. G., Capt. 36th Middlesex Rifle Volunteers.
Wilkins, Joseph W., Lieut. R.N.
L'Amy, J. Ramsay, Major, late Forfar and Kincardine Art. Militia.
Vidal, Charles J., Capt. R.N.
Beresford, Rt. Hon. Lord Charles W. De la P., Commander R.N.
Eyre, Philip H., Major 38th Regt.
Hellard, Samuel B., Commander, late Indian Navy.
Evans, H. Lloyd, Lieut.-Col., late Indian Army.
La Touche, George D., Capt. 2nd W.I. Regt.
Trist, W. S. G., Lieut. 2nd W.I. Regt.
Kerrans, Percy G., Lieut. 2nd W.I. Regt.
Clothier, Robert F., Lieut. 2nd W.I. Regt.
Norton, G. C. G., Lieut. 2nd W.I. Regt.
Dale, Charles L., Lieut. 2nd W.I. Regt.
Dutton, W. C., Lieut. 2nd W.I. Regt.
Edwards, F. J., Lieut. R.E.
Allen, Ralph E., Capt. 15th Regt.
Bradley, J. D., Capt., late 14th Regt.
Dent, Herbert W., Lieut. 2nd Queen's Royal Regt.

[1] For names of Members who joined the Institution between the 16th January and the 12th February, see No. 89, pages 116, 134.

Westbury, Lord, Lieut. Scots Guards.
Wodehouse, A. P., Capt. 69th Regt.
Aykroyd, Charles, Lieut. 3rd West York Rifle Volunteers.
Burton, C. W., Lieut.-Col. Royal Marine Light Infantry.
Browne, T. H., Lieut. 1st W.I. Regt.
MacDougall, John, Lieut. 21st Hussars.
Whittle, C. E., Lieut. 2nd Queen's Royal Regt.
Newton, William, Lieut., late 5th West York Militia.
Knowles, C. G. F., Capt. R.N.
Carleton, George, Col., late R.A.
Cockburn, George W., Capt., late 42nd Highlanders.
Menzies, Neil J., Lieut. Scots Guards.
Brett, E. L. S., Lieut. Scots Guards.
Hay, John A., Lieut. Scots Guards.
Pilkington, John, Lieut.-Col. 15th Lanc. Rifle Volunteers.
Pierce, T. D., Capt. 15th Lancashire Rifle Volunteers.
Leslie, George, Major and Adjt. 15th Lanc. Rifle Volunteers.
Hereford, R. J., Capt., late 73rd Regt.
MacDonald, D. J. K., Capt. 6th Argyll Artillery Volunteers.
Martin, William, Lieut. R.H.A.
Rose, Overend G., Lieut. Royal Lancashire Artillery Militia.
Jones, Frank E., Lieut. 37th Middlesex Rifle Volunteers.
Rainsford-Hannay, F., Lieut. R.E.
Talbot, George, Capt., late 13th Regt.
Hummel, H. W., Capt. 11th Middlesex Rifle Volunteers.
Buller, H. M., Major 1st Regt. C. India Horse.
Kelley, Henry B., Capt. Royal Lancashire Artillery Militia.
Talbot, F. A. B., Lieut. 43rd Regt.
Ball, O. J. H., Lieut. 69th Regt.
Halford, F. B., Major 19th Middlesex Rifle Volunteers.
Despard, W. F., Capt. 28th Middlesex Rifle Volunteers.
Anderson, W. T., Lieut. 80th Regt.
Nelson, F. W. G. H., Lieut. 40th Regt.
Hampton, Archibald R., Lieut. 2nd W.I. Regt.
Salmon, M. B., Lieut. 2nd W.I. Regt.
Gabbett, R. P., Esq., Assist. Commissary.
Henniker, J. M., Lord, Capt. Suffolk Rifle Volunteers.
Shirley-Ball, A. W., Capt. Antrim Art. Militia.
Lees, Hastings R., Lieut. R.N.
Steele, Laurence L., Lieut. 15th Regt.
Clarke, F. C. H., Capt. R.A.
Edwards, Charles G., Capt. 2nd W. Y. Yeo. Cavalry.
Martin, C. G. Byam, Capt., late 65th Regt.
Solly, Lewis B., Commander R.N.
Hooper, J. H. Singleton, Paymaster R.N.
Carleton, F. R. C., Lieut. 68th Regt.
Downes, M. F., Lieut.-Col. R.A.
Fendall, George N., Lieut.-Col. 53rd Regt.
Strathnairn, Lord, G.C.B., G.C.S.I., Field Marshal, Col. Royal Horse Gds.
Dalton, E. T., C.S.I., Lieut.-Col. Bengal Staff Corps.
Phipps, T. H., Capt. 7th Hussars.
Murray, H. Augustus, Lieut., late 79th Highlanders.
Lindsay, H. E. Morgan, Lieut. R.E.
Place, R. Butler, Lieut. R.A.
Bogle, John du T., Lieut. R.E.
Shaw, Ponsonby, Capt. 95th Regt.
Bedford, W. F., Maj.-Gen., unatt.
Burgess, F. F. R., Lieut. Bengal Staff Corps.
Archer, F. W., Lieut. 60th Royal Rifles.

OCCASIONAL PAPERS, NOTES,

AND

NOTICES OF BOOKS.

This portion of the Number is reserved for Articles, either Original or Compiled, on Professional Subjects connected with Foreign Naval and Military matters; also for Notices of Professional Books, either Foreign or English.

It is requested that communications, or books for review, may be addressed to

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THE SUPPLY OF AN ARMY IN TIME OF WAR.

By Colonel M. Hazenkampf, Chief of the Staff of the Russian Guard Corps.

Translated and abridged from the Russian, with the author's permission, by
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Fellow of the Geographical Societies of London and St. Petersburgh.

NOTE BY THE TRANSLATOR.

In this pamphlet, the mechanism of supply in vogue with the different European armies, is examined and contrasted. As however the arrangements for the supply of the Russian army in Turkey during the present campaign differ in an important manner from the systems herein described, it appears desirable to preface Colonel Hazenkampf's pamphlet with a few brief remarks on the causes which have necessitated a divergence from the system generally adopted.

The duty of supplying the Russian Army in the present war is not undertaken by the intendance or commissariat officials of the Government, but is handed over bodily to agents who purchase on commission, the agents being merely bound to deliver supplies in certain quantities at points pre-determined by the intendant of the army, without regard to cost. Consequently the supply is virtually out of the control of the military departments, and the efficiency of the supply depends on the ability and honesty of agents, who are in many cases foreigners.

The cause which has led to the adoption of this new system is the peculiarity of the conditions under which the war is conducted. The Russians were in the peculiar position that before reaching the enemy's frontier they had to traverse an intervening State, whose susceptibilities they must at all hazards take care not to wound. Hence a convention had to be concluded with this State, Roumania, before it could be entered. Then commenced the storing within its borders of supplies for the use of the Russian army, a matter of considerable delicacy; disregard of the feelings of the inhabitants might at any moment lead to a rupture of these good relations, an eventuality which could not fail to increase enormously the difficulties of the Russians, even if, in the sequel, it did not bring other Powers into the field. That most certain means of supply, requisitions, could not of course be thought of, and the more expensive and less certain means of purchase on commission had to be adopted. Again, Roumania does not produce rye, the staple food of the Russian soldier, and it is a country, moreover, where the population is scanty and poor, the roads bad, and transport far from abundant. This transport, like the food, could not be requisitioned; its collection must depend more or less on the good pleasure of the inhabitants. Had Roumania been provided with a good railway system leading from the Russian frontier to the Danube, the difficulties of transport might have been overcome, but that State is peculiarly ill-situated in this respect, as there is but a single railway with a single line of rail, and moreover recent experience is said fully to bear out its reputation of being the worst laid line in Europe. If it be added to this that there is a break of gauge at the Russian frontier, requiring all stores to be shifted to trucks of smaller gauge, we can understand how much the difficulties of supply have been enhanced.

Arrived at the secondary base on the Danube, the difficulties were by no means over. Supplies have then to be passed across this broad river over temporary bridges, liable to danger from freshets and from the enemy's gun-boats, for the Danube does not possess a single permanent bridge at this part of its course. On the further side, in Bulgaria, a country had to be looked forward to with a population half-starved and decimated by epidemics, and with its supplies probably removed or destroyed by the foe.

The difficulties of the Russians in organising their supply service may be summed up as follows:—(1.) The Russian railway system does not lend itself to a concentration on the south-west frontier, nor to the formation there of a base of supply. (2.) The secondary and real base on the Danube had to be formed on sufferance in a friendly State, while communication with the primary base was most defective. (3.) The system of requisitions for obtaining supplies from local sources could not be used.

Our present information is too meagre to form a judgment as to whether the new system has failed or not; there have no doubt been shortcomings, but it must be acknowledged that under the circumstances, the feeding of an army of 300,000 men is no light task. Compare the conditions with those of the German Army in France, 1870–71, where the theatre of war was rich, highly cultivated, and well populated, provided with good roads and railroads, by which supplies could be forwarded without a break from the heart of Germany to the walls of Paris.

The question of the supply of an army in time of war is the most important and most difficult of all administrative questions. No one will dispute the fact that on the degree of certainty of their supply, depends the fitness of troops for the field, and consequently the success of the campaign. The important influence of this question on the fate of campaigns does not admit of doubt. If we turn to military history, we find that insufficiency of supplies has always retarded the progress of operations; has sometimes necessitated changes; has hampered the boldest and most skilfully laid plans; has often forced military movements to be arrested at a time when a decisive blow was alone wanted to attain the desired object; lastly, in some cases, has ruined entire armies, and decided the fate of the campaign.

In proof of our statement, we would instance a few cases from the military history of all times, commencing with the earliest.

Let us call to mind the campaign of Darius Hystaspes against the Scythians (513 B.C.). The Scythians had recourse to the same procedure which was followed by the Russians in 1812. Being unable to resist the army of Darius, numbering some 700,000 men, they avoided general actions and, retreating before the Persians, enticed them further and further into the depths of the desert. In a short time of course there was a dearth of supplies, from which time Darius' army commenced to diminish with great rapidity, without even once coming into collision with the foe. Seeing that the army must inevitably perish of hunger, Darius was obliged to give up his design of conquering the Scythians, and returned home with the remnant of his army.

A second example from ancient history: when Alexander of Macedon, after subjugating the country along the lower course of the Indus, proceeded to make his return journey to Babylon, he divided, as is well known, his army into three columns. The left was embarked in ships; the central was marched along the sea shore and the Persian Gulf, while the right was directed through the deserts of Hedrosia (present Afghanistan) upon Persepolis. The first two columns returned in good order, but the last (80,000 men), led by Alexander himself, perished of hunger nearly to a man.

In the middle ages, as is known, a large number of Crusaders also succumbed to hunger, either on the march or in camp. It may be said with the greatest probability, that had there not been a deficiency of supplies, the object of the Crusaders, the subjugation of Palestine, would have been achieved.

Recent military history presents us with an entire series of such examples.

In 1792, Dumouriez, after gaining a brilliant victory at Jemappes, conquered at one blow the whole of Belgium, and might have carried his incursions into Germany,

but the utter want of stores forced him after this decisive victory to suspend his movements, and first to take in hand the organisation of the supply service of his army. Although he overcame this difficulty for a time, and penetrated almost to the Rhine, yet his plans proved abortive, owing to the complete dissolution of his army, which became first demoralised from want of food, and afterwards corrupted by pillage, to which it was forced in order to satisfy its most pressing necessities.

Then let us call to mind, that in 1812 the first cause of disorder in Napoleon's army was due to the fact that he had insufficiently elaborated the system of supply, that he did not make his mode of conducting war harmonise with the local circumstances, that he did not take into consideration the difficulties of a rapid transport of supplies in a country like the Russia of those days: vast in extent, poor, sparsely populated, and with an imperfect road system.

Then, as is well known, the Khivan expedition of Perovsky in 1839–40 ended with the almost complete annihilation of the detachment, because the arrangements for supply were not consistent with the conditions of steppe warfare.

During the Polish campaign, the inefficiency of the supply service hampered the course of military operations and prolonged the war over several months, whereas it might have been finished in three or four weeks.

In 1854, the difficulties of supply, among other reasons, were the cause of the war being transferred from European Turkey to the Crimea.

As is well known, the military operations commenced on our side with the occupation of the Danubian Principalities, and the first object of the campaign on the part of the Allies was to force us to evacuate them. To this end the allied army of 80,000 men was transported by sea from Constantinople to Varna.

But in a very short period this army lost 15,000 men from sickness, partly due to the baneful climate and partly to insufficiency of food.

It was then resolved to transfer the seat of war to the Crimea, but in order to conceal this plan, an expedition was made to the Dobrudja against our detachment of 10,000 men posted there.

This expedition, of which the French General Espinasse was appointed commander, was attended with ill-success, owing to the villanous climate and the dearth of food.

Of course many other examples might be cited to prove the vast importance exercised by the supply service over the operations, but it appears to us that the object has been sufficiently attained by the few examples which we have adduced. Such an essential and important question as the organisation of the supply service must evidently be examined from all points of view, otherwise it is impossible to have a clear idea of it.

First of all we will detail and examine those conditions on which mainly depend the supply of the army in time of war generally, and then pass to a consideration of the various systems employed. In doing so, with a view to clearing up the question as much as possible, we shall turn once more to military history, and review briefly the various methods which have obtained at different historical epochs.

The supply of troops in time of war depends on a number of very complex and varied conditions. The most important of these are the following:—

1. The resources of the theatre of war: the most essential being (*a*) the productiveness of the country, (*b*) the distribution of wealth, and (*c*) the facilities for turning them to account, in which the condition of the communications will naturally play an important part.
2. The time of year and the climate.
3. The mode of conducting war, *i.e.*, offensive or defensive.
4. The length of the line of operations.
5. The rapidity of the movements.
6. The distance to the enemy.
7. The administrative organisation of the theatre of war.
8. The temper of the local population.

It is unnecessary to observe that the efficiency of the supply depends upon the association of these conditions; some according to circumstances are given more prominence, while others influence in a less degree. In what manner the association

of all these conditions influences the organisation of the supply service, it is impossible of course to define, as every given case has its own special combination of influencing elements. Hence we can only examine the importance of each of the conditions separately.

For the successful provision of an army, with its necessaries of life, is required, in the first place, a thorough knowledge of the resources of the country which is to be made the theatre of war, as a skilful use of those resources constitutes the surest guarantee for the rapidity and decisiveness of the operations; this is the only means of supply which entirely frees the hands of a commander. And, however hard it may seem to wage war at the expense of the innocent inhabitants, circumstances sometimes will not permit of any other course. We must always bear in mind, that if it becomes necessary to go to war, our main efforts must be directed to bringing it to a speedy conclusion. If there is a possibility of attaining this object by humane means, so much the better; if not, we must have recourse to severe means. Let us give an example: the most effective and humane method of supply is unquestionably by purchase for cash, collected by contributions. But if there is neither money nor supplies, then *nolens volens* we must take them from the inhabitants by force, without any regard to the equalisation of the burthen. Under such circumstances it is impossible to be strictly equitable; we must take what we can get.

A thorough examination of the resources of the theatre of war is, we repeat, essential to the successful supply of an army.

To study the resources when war is already declared is too late; it is necessary in time of peace to have accurate, concise, and systematically arranged statistics of all those countries which are likely to become the theatre of military operations. This duty devolves upon the general staff.

For supply considerations it is necessary to know :—

(*a*) What is the chief produce of the country.

(*b*) How are its resources distributed.

(*c*) To what extent can they be made use of.

Above all things we must know the chief wealth of the country: in agriculture, in cattle, or in industry and trade.

Countries which are mainly agricultural, present as a rule the most convenient theatres of war from a supply point of view; in such countries, the army can live *longest* on the local resources, and at the same time its operations are least hampered by supply considerations.

On the other hand, in countries where manufacturing industry is most developed, supply becomes more difficult. In such regions it is more easy to find *money* for the purchase of supplies, than, as a rule an abundance of stores in kind. Lastly, in countries where cattle breeding preponderates, an army will probably not find stores of flour in excess of the local requirements, while on the other hand meat, forage, and transport will be guaranteed.

These data relating to the character of the industry can only serve for general considerations, we must also know—

How great are the local demands on the supplies, and therefore what is the population of the theatre of war?

Are the local requirements covered by the internal resources, and if not, whence is the corn received?

If the country produces corn in abundance, then how large is the export, and whither is it sent; where in this case are the corn markets and stores, and by what routes does the corn trade pass?

What is the number and power of the mills, and where are they situated?

Was the last harvest abundant or the reverse?

What is the extent of the resources in horned cattle and horses?

The necessity of most of these data is so evident, that there is no need to explain their importance. But with regard to some of the above conditions, a few words must be said in order to show to what extent they bear upon a successful supply.

Thus, for example, *the number of inhabitants in a country* of itself means nothing; in order to judge, with regard to the population, how far the local supplies can be

calculated upon, it is necessary to know, (1) how the population is distributed, and (2) how it is employed.

Generally speaking, the greater the relative population, that is to say, the greater the number of inhabitants to the square mile, the more considerable is the annual demand, and therefore the smaller the area and the shorter the time in which provisions may be collected. But in some localities the number of the population cannot serve as a measure for determining the amount of the local supplies. In manufacturing centres, for example, the population is dense and rich, but it uses imported corn, and therefore in such countries one cannot count upon the local supplies. Hence in drawing conclusions with regard to the supplies of a country from the number of its inhabitants, we must not take into consideration the population of the manufacturing and industrial centres, nor the population of the towns generally, as the towns themselves do not produce supplies, but only consume them. Towns only have importance as points in which there are always supplies over and above the local requirements. In this respect the population of a town naturally has a great importance; the larger and more populous the town the greater the quantity of supplies which may be expected. It is of course understood that a town has great importance if it is the centre of a corn trade.

The next question is what practical deduction can be made with regard to the degree of possibility of supplying an army from the resources of the theatre of war, where its relative population is known?

From the experience of former wars we have come to the following general conclusions :—

(1) If the population of a given point or locality be equal to the number of troops, it can supply them for a period of four, but not more than six days.

(2) If the number of troops be half the number of the population, they can be maintained at the expense of the latter for one or two weeks.

(3) Lastly, the number of troops being a quarter of the number of inhabitants, they can be supplied for a space of three to four weeks.

An army corps of 60,000 men can be easily supplied from the means of a country which has 150 inhabitants to the square mile, but only while on the march. It must not halt at one place in a concentrated position.

Passing now to a consideration of the influence which the *number and power of the mills* has on the theatre of war, we would remark, that this influence is far more significant than appears at first sight. With an insufficient number of mills, the largest stores of corn would prove useless, and the army might be placed in a difficult position even in a country abounding in that commodity.

It is well known that the bulk of the corn stores, particularly in villages, is kept in grain. Large supplies of flour are only found as an exception. Hence the information as to the number and position of the mills in a country is almost as important as knowledge as to its productiveness. It is necessary to know also the description of mill, whether steam, water, wind, horse, or hand, as some of these cannot always be calculated upon. Windmills, for example, are little worked in summer, watermills do not act in frost.

In highly cultivated countries a sufficient number of mills will of course be found, but where cultivation is poor, there the number and power of the mills is limited to the ordinary local requirements, as the export is in grain. Hence if in such a country the troops also require flour, it may easily happen that they will suffer from an insufficiency of bread, even where there is an abundance of grain. In order to make this more plain we will cite an example. Let us suppose that in a country well populated, having for instance 100 inhabitants to the square mile, there is such a number of mills as could grind even *double* the quantity of grain necessary for the local supply. If in such a country an army of 300,000 men be concentrated, then in order to grind merely one day's supply of flour for this force, it is necessary to set in motion all the mills within a *rayon* of 1,500 square miles for 24 hours. As an army does not however remain stationary, but is in constant motion, it is impossible to limit the grinding to one day's requirements, and it becomes necessary to grind at least a three days' supply. But for this purpose we shall have to employ the mills for a distance of 4,500 square miles; and before this can be done, the grain must be brought to the mills,

while afterwards the flour has to be delivered to the troops or to the magazines. All this demands so much time that the supply of the army will be inevitably interrupted.

After this theoretical example let us pass to one of history. During the Crimean War our army could not make use of the large stores of corn collected in the ports of the sea of Azoff, solely because these stores were in grain, and to grind it with the available means was an impossibility. We had to bring flour to the army from the Yekaterinoslav, Voronej, Kharkoff, and Kursk Governments, while vast stores which would probably have quite sufficed for the supply of the army, were useless.

From this it is plain that the supply of the army from local resources can only be considered as guaranteed where the stores of corn are in flour, or when the theatre of war has an abundance of mills.

But it has been already said that we cannot expect to find large stores of flour; while the certainty of obtaining mills is not always to be depended upon. It is by no means certain that all will be available, while the enemy may render them useless. Hence the importance of hand-mills.

These mills have been in use from a very distant date. The Romans had them; pack animals with hand-mills toiled after the legions of Scipio.

In the last century, before his campaign into Russia, Charles XII had his entire army provided with them, and this precaution stood the troops in good stead, as they, in retreating, destroyed all the mills.

In the army of Frederick the Great, during the Seven Years War, each company had a hand-mill.

Napoleon, when undertaking the campaign against Russia, and with the experience of the Spanish War fresh in his recollection, foresaw the insufficiency of the local means for grinding, and ordered in consequence 5,000 hand-mills for his army. But these mills were delivered in Russia, and only reached Smolensk as the army was returning from Moscow, and then the mills were of no use, as there was nothing to grind.

Our army, during the Turkish War of 1828–29, was also provided with cast-iron hand-mills, but they ground little, and soon got out of order, and proved only an incumbrance. Hence in the Hungarian War these mills were no longer used, but the troops ground their corn with hand grindstones, which were purchased on the spot.

We must finally allude to the influence exercised on the supply by the quantity of horned cattle and horses in the theatre of war.

The quantity will give an idea—

1. To what extent we may look for meat for the troops.
2. What quantity of forage, more particularly hay, may be found; the question, owing to the difficulty of transporting hay for any distance, has very great importance with regard to supply.
3. In what quantity, over what area, and in what time, transport may be collected for the carriage of food and other stores.

Passing now to a consideration of that influence which the *distribution* of local supplies has on the success of feeding troops, we will remark first of all, that this distribution, in the main, depends on the distribution of the population and its mode of life.

If the population be dense and in large villages, then the supplies are concentrated, consequently they may be easily obtained in large quantities and in a short time. But if the population, although numerous, be scattered or dispersed evenly in small villages, the supplies are found at a large number of points, but in small quantities. This impedes and retards the collection, and in consequence hampers the mobility of the army, or forces it sometimes to occupy a *rayon* more extensive than is desirable on strategical grounds.

This exercises a great influence on the success of supply from the local resources. Thus, for example, in those of our Governments which abound in corn, Kieff, Volhynia, Bessarabia, &c., the collection of supplies by requisition could only be effected very slowly, as the collection would have to be extended over a wide area. In Poland, where the population is more dense, and the territory smaller, the French

Army in 1806–7 could not supply itself exclusively by requisitions, because the *rayon* necessary for supply was at the same time very extensive. On the other hand, in France, in which country much less corn is grown than with us, the vast German army met with little difficulty in its supply, during the campaign of 1870–71, because the supplies were concentrated in large quantities at local centres, and in consequence could be easily and quickly procured.

The mode of life of the inhabitants, if it is in sharp contrast with that of the troops, will not be without influence on the supply from local resources.

Thus, for example, the inhabitants of the Danubian Principalities, although they grow corn, do not themselves consume it, but eat *Mamaligoi, i.e.*, dough made of maize. In consequence of this, when operating in the Principalities, it is quite impossible to count upon stores of flour, local mills, or bakeries, but it becomes necessary to take measures for guaranteeing the supply of the troops by carrying flour, or to provide them with hand-mills, and the means for establishing field bakeries.

Let us now consider to what extent the supply depends *on the facilities for utilising* the resources of the theatre of war.

This depends primarily and mainly on the condition of the routes of communication.

Military history presents a mass of examples irrefutably showing that an army may suffer from want even in the richest country, if the means of communication be in an unsatisfactory state. The cause of this is that *the difficulty of providing an army with supplies* consists not only in the collection of the necessary quantity of food, as *in bringing it up in time and distributing it to the troops.* However vast the stores may be, they are of no use if they cannot be brought up in time, or if they cannot be conveyed after the army.

Thus for example in the campaign of 1812, the French Army suffered from want of supplies, not from their insufficiency, but from the impossibility of bringing them up rapidly. Supplies were provided in abundance, but the bad state of the roads did not allow of their transport with the same rapidity as the army moved. The result was the same as if there had been no supplies at all. Another instructive example of the importance of means of communication is afforded by the Crimean campaign. Although our army did not suffer from want of supplies, their delivery was attended with incredible difficulties, and cost immensely, because the roads were few and in a most wretched state. In the course of nearly two years, an army of 200,000 men was concentrated in a small area, separated from the internal corn-growing Governments by 200 miles of steppe, on which there was but one road and that not a *chaussée.* All that could be done for the improvement of the line of communication, consisted in constructing at great difficulty and expense a *chaussée* between Simpheropol and Sebastopol. All articles of prime necessity had to be brought to the army from a distance, at first from 200 miles, afterwards, as the country nearest to the theatre of war became exhausted, from 400 miles, and lastly 600. These distant transports had to be effected in the worst weather, as the war in the Crimea had to be conducted at the most unfavourable time of year: two Autumns, two Winters, two Springs, and only one Summer. In consequence of this the slowness of delivery was extraordinary. Country carts with supplies took a month and even longer to perform the 85 miles from Perekop to Simpheropol, or less than three miles a-day. By post it used to take ten days at the rate of eight miles a-day. These facts may give an idea over what sort of impassable mud lay our sole line of communication.

Our antagonists being masters of the sea, were in an incomparably better state, but they themselves had to experience what a bad road means. The land transit consisted of a distance of six miles from *Balaclava to the camp,* and notwithstanding this, the transport was exceedingly difficult until the railway was constructed in March, 1855.

Lastly, the Abyssinian campaign of 1867–68 could only be carried out by making a road, as the operations had to be prosecuted in a country where there were no roads and no supplies whatever. In spite of the large expenditure and the difficulties presented by the mountainous locality, the English were compelled to construct a road, partly rail and partly ordinary, from the point of disembarkation to Magdala, as otherwise there was no possibility of bringing up stores to the troops.

From these examples we see that the state of the routes of communication has a very decisive influence on the success of supplying an army. If we had had a railroad in the Crimean War, the supply of the army would have been five times as cheap, to say nothing of the rapidity of bringing up supplies. The circumstance that the army remained nearly two years on the same spot, would have served to simplify and improve the supply service, had there been good roads. But from want of these, this very circumstance only hindered supply and increased its cost.

As to the influence of the time of year and of the climate of the theatre of war on the success of the supply we shall not dilate, as this influence is very evident. Let us see what influence the form of conducting war and the length of the line of operations have in this respect.

Generally speaking, it is much easier to arrange the supply service when on the defensive than on the offensive. The defender is acting in his own country, and has the possibility of organising a regular communication with his depôts and magazines; the assailant, on the other hand, is gradually receding from his supplies, and in consequence the transport becomes more and more difficult as he advances. The assailant has to rely upon the resources of the theatre of war; if these means be insufficient, or the roads bad, he may be placed in a very critical position.

In this case the success of the supply depends to a considerable extent on the length of the line of operations; the longer that is, the more difficult the supply. In a poor country, the supply of the army has to be based on bringing up stores, and the longer the line of operations, the less surely can the transport be depended upon.

As examples to what extent the difficulty of transporting supplies will grow with the increase in length of the line of operations, we may instance the wars of 1812, the Crimean and Abyssinian (1867–68) campaigns.

The chief base of the English in this last campaign was Zoulla, on the shores of the Red Sea. Afterwards when Zoulla was connected with Coomailo by a railroad, the supplies were partly transferred thither. From Coomailo to the interior an ordinary road was constructed. When the English detachment of 13,000 men was at Antalo, *i.e.*, 16 marches from Coomailo, a pack train of 16,000 mules was organised for carrying their supplies. This train was divided into 40 transports of 400 mules each. This arrangement was founded on the number of days' march from the base to the detachment and back, including halts and the time necessary for loading and unloading. Thus each day 400 mules were sent from Coomailo towards the army, and the same number had to come daily to the detachment.

But without speaking of the fact that as the detachment moved onward, it became necessary, for its uninterrupted supply, to increase the pack train to 800 mules for each march made by the detachment, this vast transport could not guarantee the detachment with supplies, in consequence of the great length of the line of operations. The mules had to carry not only the supplies for the detachment, but for themselves and their drivers, for the entire 40 days' journey to the detachment and back. Of course as the line of operations lengthens, the quantity of supplies which the pack train has to carry for itself increases, and consequently the quantity which it brings for the detachment is diminished. Hence the time must arrive when the quantity of stores brought daily to the detachment does not satisfy its requirements. And therefore as we move onward the train has to be increased more and more. The English formed fresh pack transports, and moreover, detachments of bearers—natives—men and women, and notwithstanding this, the supplies reached them in insufficient quantity, particularly as they neared the ultimate object of the campaign, Magdala, the residence of the Emperor Theodore. The distance of Coomailo to Magdala was in all 370 miles: had the English had to penetrate more deeply into the interior, a time would eventually have arrived when no transport would have ensured their supply, as everything would have been expended on the road by the bearers, the pack animals and their drivers.

Of course this example is an extreme case, because it is the exception for the line of operations to pass through an entirely desert country. But in those countries where the local resources can be calculated upon to a considerable extent, the difficulty of transport is increased in a directly proportional degree to the length of the line of operations, (1) because the quantity of transport required is increased;

(2) because the slowness of movement of the trains is increased as their dimensions expand, and as the distance lengthens which they have to traverse.

The influence of the length of the line of operations is very much diminished when the supplies can be brought from the base by railroad. In this respect railways cannot be surpassed. But at the same time it must also be taken into consideration how easily this means of communication can be interrupted, particularly in an enemy's country, where the local population is hostile.

The degree of rapidity of the movements of the troops has no slight influence on the supply.

It is evident that if troops remain stationary, the transport of supplies is facilitated in all cases, but particularly when the communications are good. But if the troops be supplied from the resources of the country, a prolonged sojourn at one and the same spot exhausts the country and its immediate neighbourhood, so that sooner or later (according to the degree of abundance of stores in the country) we shall have to look to the supply from the rear. At the same time the less the troops are concentrated, the longer they can live at the expense of the country.

If the troops are in movement, the facilities for utilising the resources of the country will depend on the breadth of the strategic front. The broader this front the easier the supply, and *vice versâ*. Hence the well known saying, "Fight con-"centrated, march separate." The facilities for bringing up stores, whether distant or near, are directly proportionate to the rate of march, *i.e.*, the more rapidly the troops move the more difficult to supply them, and *vice versâ*.

Large masses moving concentrated and rapidly, can scarcely ever live at the expense of the country, however rich it may be, as there is no possibility of collecting the supplies in time and delivering them to the troops. In such a case only the leading detachments of each column can make use of the resources of that locality through which the line of operations passes. Hence the greater part of the troops will be fed from the rear. As we have already said, the more completely the transport guarantees the requirements of the troops, the more rapidly they move.

Consequently there must be a limit to the number of troops which can move in one column. Beyond this limit rapidity of movement becomes speedily paralysed by difficulties of supply, as it is impossible to make use of local resources, nor can the train arrive in time. Experience shows that not more than 60,000 men can move by one road.

From what has just been stated, the influence which the propinquity or otherwise of the enemy exercises on the supply of the troops becomes evident. It compels them to be quartered and to march concentrated, consequently hampers both the supply from local means as also the bringing up of stores; moreover, as the enemy is approached, the number of unforeseen incidents increases, rendering supply difficult, and sometimes bringing it to a complete standstill.

The success of the supply of an army from the resources of a theatre of war depends to a considerable extent upon the administrative organisation of the country. Both the collection and conveyance of supplies proceeds with incomparably greater ease and rapidity with the aid of the local authorities, than by the mere order of the intendance, little, and sometimes, totally unacquainted with the local conditions, with the productive power of the country, with the distribution of supplies, with the manners, customs, and language of the inhabitants.

Hence in order to ensure the supply at the expense of the theatre of war it is necessary to have at disposal regularly constituted local authorities. In the absence of these authorities supply from that source becomes most difficult and sometimes simply impossible. An administration of one's own has to be organised; but in the first place this cannot be so easily and quickly done as it would appear; secondly, even if it succeeds, until the newly appointed officials become acquainted with the local conditions and circumstances, the army will suffer from want and every possible inconvenience. As regards the country itself, the arrangements of men unacquainted with it exhaust it in the shortest time, and this ultimately reflects unfavourably on the troops.

The absence of a local administration may lead to another class of evil, to forced requisitions by the troops themselves. But we have already had occasion to mention the unfavourable influence such requisitions exercise upon the army.

Lastly, the utilisation of the resources of the country and the means of supply are generally in direct dependence on the temper of the local inhabitants.

If they be favourably disposed, then of course supply is facilitated. If the local authorities be passive, the whole task of turning the local resources to account depends entirely upon moderation and tact in not exasperating the people by excessive and unjust demands. But if the inhabitants be hostile to the troops the task of supply is generally most difficult, and particularly so when the population does not limit itself merely to concealing its supplies, but takes an active part in the military operations. In this case it is impossible to calculate either upon the means of the theatre of war or upon a well timed and sufficient transport of stores. No matter how great the foresight or how rigid the measures, an energetic population will always find opportunity for damaging the communications of the army. During the expedition to Egypt, Napoleon had to fortify and protect every well with troops; in 1812, as every one knows, the Russians converted the entire zone of operations of the French into a waste. From the chain of partisan detachments surrounding Moscow, Napoleon was never able to rid himself. Lastly, in 1870-71, despite the rigorous measures adopted by the Germans, they could not entirely protect their communications from the attacks of Franctireurs. On some of the railroads every signal box was occupied by a detachment, but in spite of this the communications were repeatedly interfered with.

General conclusions as to the conditions which influence the supply of an Army in War.

Regarding as a whole the various conditions which influence the success of supply in war, we may say that the main difficulty lies in adapting commissariat necessities to strategical requirements.

Thus for example, the more the forces are concentrated, the more advantageous on strategical and tactical grounds, and the more unfavourable as regards supply, which demands as large a dispersion as possible.

In the present day, the supply of an army, in spite of the increase of wealth and cultivation generally, and notwithstanding the mass of railroads, &c., has become more difficult than formerly. The last Franco-German war inaugurated a new era of warfare: not between armies but between *armed nations*. Future wars will be waged with the application of the whole force and means of the Government, as only under this condition can we now count upon success. But terrible wars cannot be of long duration, they must of necessity be ended as quickly as possible. Hence the general character of future warfare may be summed up in four words: vast force, great mobility.

Both these desiderata are antagonistic to the conditions of a favourable supply of the army. To organise it on a large scale in a short time, to equilibrate the rapidity of transport with the rapidity of the army's movement, is no light task.

To foresee the turn military operations will take is impossible, circumstances change constantly and unexpectedly. Accidents of every kind render abortive the best pre-considered plans; problems, which war so unexpectedly presents at every step, demand rapid decision and immediate execution; faulty arrangements can only be corrected in time under very exceptional circumstances, while the consequences of those arrangements may be incalculable. Much easier is it to correct a faulty direction given to troops than to change in time wrongly directed supplies.

With all this before us, it is impossible not to acknowledge that the organisation of the supply-service in war is really one of the most difficult tasks of military science.

At the commencement of a war, when troops are only concentrating, supply does not present any great difficulties.

It is known beforehand where and in what quantity stores have to be collected; hence there is time and opportunity to make all the necessary arrangements.

But with the commencement of military operations begin the supply difficulties. And the larger the army, the more concentrated and rapidly it moves, the further it advances, the fewer the roads and the worse their condition, and lastly the poorer the theatre of war, the more do these difficulties increase.

The broader the strategical front of the army, the more easy does it become to utilise the resources of the theatre of war; on the other hand, the narrower it is, the more will the army depend on movable supplies. The more numerous the army, the more concentrated it moves, and the more prolonged its movement, the more considerable must be the amount of its carried supplies, *i.e.*, the larger must be its train. But the larger the train the less the mobility of the army.

In these few words is summed up the whole difficulty of adjusting the organisation of the supply-service to the strategical and tactical conditions of the present day.

Many affirm that with the development of railways the task of supplying troops in war is solved, that by virtue of these perfected means of communication the supply difficulties are entirely removed or nearly so.

But the real point is that it becomes impossible to use railways at the very time that the difficulty of supply increases: when the enemy is near. In proportion as we approach the antagonist, the importance of wheeled transport increases, and ultimately it becomes the sole means. Moreover, it is impossible to forget that if, on the one hand, the contemporary development of cultivation, national wealth, and of the railway network facilitates the utilisation of the means of the country, and the movement of supplies, yet, on the other hand, the enormous numerical increase of the army, and the rapidity of its movements, militate against both.

Railroads have not established complete equality between the rapidity of military operations and the rapidity of moving supplies. Yet in their due transit and delivery at the point and at the time where they are required, lies the whole difficulty of supplying an army in time of war.

Here we will conclude our general sketch of the conditions on which supply depends in time of war.

Before we proceed to consider the different modes of supplying an army in the field in the present day, we will give an historical summary of the methods which formerly existed. This sketch will serve as a proof, that the system of supply has been at all times in intimate connection with the mode of conducting war.

In ancient times and in the middle ages, until the invention of gunpowder, the army lived exclusively at the expense of the theatre of war, and knew no lines of communication. War paid for war in the full sense of the word. There were no magazines, no transports; on the contrary, wars were often conducted with the express purpose of gaining wealth at the expense of one's neighbour.

Of course, under such conditions, every war ended with the complete desolation of the country which had the ill-luck to become its theatre.

Hence in those times supply presented no difficulties. Moreover, the wants were very moderate. Naturally it often happened that whole armies were dispersed or perished from deficiency of supplies, as was the case, for instance, in the time of the Crusaders.

With the invention of fire-arms, the mode of conducting war, and the system of recruitment changed, while at the same time a new system of supply gradually supervened.

The invention of fire-arms demanded the transport of warlike stores, consequently the necessity arose for a regular communication with home territory. In other words, the idea grew of a base of military operations and of lines of communication.

At the same time the change from an army of knights to enlisted troops was accomplished. On account of the limited state of the finances, an enlisted army could not be numerous; up to the 16th century their number never exceeded 50,000 men.

Generally speaking, the invention of fire-arms gave an impetus to bringing all branches of the military art into order and system. Enlisted armies were too costly to the State to be left to chance, hence arose a necessity for a regular organisation of their supplies.

As early therefore as the 14th century, we find attempts to change from a disorderly

plunder to a systematic use of the resources of the country. Thus in 1311, the French King, Philippe le Bel, first established magazines for the supply of the army; in the same century in Germany, we find for the first time the troops systematically quartered on the inhabitants; at the commencement of the 15th century we find the Austrian army provided with movable supplies, which arrangement was however borrowed from the Turks. The Turks were the first to fix the daily ration of a soldier and the first to have a train in their wake.

Subsequently in the same 15th century, Louis XI of France was the first to organise a supply administration with his army; at the commencement of the 16th century, war commissaries and provision-masters also appeared in Germany.

Lastly, in the same century, we find the rule first expressed in Germany, that as long as military operations are undertaken *in home territory*, nothing should be taken without payment, but supplies purchased of the inhabitants for ready money. The soldiers were ordered to pay for their purchases, as they received a sufficient wage.

The armies of those times being small, this means of supply presented no difficulty, particularly in the case of operations in a wealthy country. Traders came to the camp voluntarily in great numbers, some of them followed in the train of the troops; hence the appearance of suttlers.

Of course the system of purchase for ready money was not always observed. If the Government was behindhand in the issue of pay, or if the soldiers themselves squandered it, plunder again became the chief means of supply.

During the wars of the Austrians with the Turks, appeared, lastly, the commencement of the magazine supply, as these wars were carried on in the steppe where no provisions could be bought. In the middle of the 16th century, the Emperor Charles V was the first to introduce field ovens.

During the Thirty Years' War, Gustavus Adolphus placed his supply system on a systematic basis.

This was the first commander who understood how to adopt the various means of supply to circumstances. If the army was in camp or on the line of march, he supplied it exclusively from magazines, both fixed and mobile, filling them by purchase, contract, or requisition, whichever appeared the most convenient. When the troops were distributed over a large area, they were rationed by the inhabitants at a fixed rate of remuneration; when closely concentrated, the food was issued from magazines, while the inhabitants were required to cook the soldiers' meals. The daily rations were accurately laid down for each soldier (1 lb. of meat and 2 lbs. bread) and horse. The quartering was arranged by special quartermasters; the collection and distribution of stores by provision-masters. The unauthorised occupation of quarters and illegal requisitions were forbidden under pain of death. The amount of train was also fixed on the basis that the troops should have with them the necessary supplies without being cramped in their movements.

In the German and French armies, the same systems of supply obtained as we have just mentioned: the purchase of supplies by the soldiers themselves for ready money. But as the treasury of the German Emperor was very rapidly exhausted, the pay became irregular. The want of money for the purchase of supplies led to a return to pillage. To this the Swedish troops also reverted soon after the death of Gustavus Adolphus. We will not descant on the serious ravages which were inflicted on the peaceful inhabitants by both combatants; they are but too well known to all who have studied history.

After the horrors of the Thirty Years' War, all the European Powers felt the necessity of improving the organisation and discipline of their armies. As the primary cause of the unbridled license of the troops in the Thirty Years' War was due to the system of pillage, the question of a regular organisation of the supply service became the first consideration.

The well known war minister of Louis XIV, Louvois, was the first to solve this question with the idea of an exclusive supply from magazines alone. This system was speedily adopted by all the European monarchies, attained its highest degree of development in the 18th century, and was maintained until the French Revolution.

But this change to a regular system of supply was accomplished not to the

advantage, but to the detriment of the development of the military art. The attractions of the magazine system became by degrees so great, that supply considerations completely out-weighed those of strategy. The greatest generals of that day, Turenne, Condé, and Montecuculi, made it their first aim not to lose connection with their magazines and not to break the regularity of the transport of stores. The object of war was ignored; instead of endeavouring to deliver a decisive blow at the antagonist, they strove to be the more cunning in seizing his magazines, capturing his transports or severing his communications. They left out of view the possibility of supplying the army from the resources of the country, while at the same time, with the small numbers of troops in those days, this would have been the easiest and most convenient mode of supply. The founder of the magazine system, Louvois, went beyond the rest in fostering it. He entirely subjected strategical considerations to those of supply, and deprived the commander of all independence. Taking under his management the supply of the troops, he distributed his army not according to strategical considerations, but entirely as to where it was most convenient to form the magazines. Naturally such considerations led sometimes to absurdities. Thus for example in the time of the war of the Spanish Succession, in 1704, the French erected a whole series of fortresses throughout the district between the French frontier and the middle Danube (to Donauwerth), expending for the purpose 40 millions of francs, a very large sum in those days. All these magazines fell into the hands of the enemy, as the result of a single battle at Hochstädt on the Danube between Ulm and Donauwerth.

Lastly, during the war in the Netherlands of Louis XIV, the magazine system of supply ultimately led to the well known *five-march system.* We shall not enter into a detailed exposition of this system, but will merely call to mind that the essence of it consists in the army not proceeding further from its magazines than five or seven marches at the most. If it became necessary to proceed further, a fresh line of magazines and ovens had to be formed, and until they were completed the army could not move from the spot. In this way it became necessary to stop periodically the movement of the troops in order to give time to bring up the stores to the newly formed magazines.

For the offensive, this merely rendered the progress of the operations slow, without offering any difficulties, but in a retreat, it was almost impossible to remove the magazines to the rear; they generally fell into the hands of the enemy. Flank movements with the five-march system were nearly impossible.

In a word, the five-march system led to the following results:—

1. Military operations were placed in complete dependence on supply considerations.

2. In consequence of this, generals began to pursue small and subordinate aims; being cramped in their movements, they could not take advantage of their victories. To conceal their plan of operations was also rather difficult, as the antagonist could conjecture it from the positions of the magazines. From all these causes wars became indecisive and prolonged.

3. Lastly, wars were costly, both on account of the system itself, and because it prolonged the war.

But we may point to two generals of the 18th century, who allowed themselves sometimes a full, sometimes a partial, breach of the five-march system. These were Prince Eugene of Savoy, and King Charles XII of Sweden. Of course this gave them immense superiority over their adversaries, who slavishly followed routine.

Even Frederick the Great, in spite of his genius, could not separate himself from the principle of the five-march system. He only perfected this system by hastening the movement of the bakeries and increasing the train, so that he could proceed seven and sometimes ten marches from his magazines. But further than ten he could not go; on the 11th day it was necessary to halt, so as to give time to move the line of magazines.

The five-march system did not fall into disuse until the revolutionary wars. The French relinquished it for the requisition system, not from conviction of its superiority, but simply from the pressure of circumstances. They had to carry war nearly throughout Europe, and all the time there was no money. *Nolens volens*

they had recourse to requisitions, not excluding their own country, as only by this means was it possible to clothe, arm, and maintain those vast armies which were formed. Of course, after this the French met with no difficulties in founding on this same system all their operations in the enemy's country. Having abandoned the magazine system and deriving their supplies at the expense of the theatre of war, the French armies recovered for themselves perfect freedom in their operations. The results are known.

The requisition system of supply adopted by the French took ultimately the following form in the Napoleonic wars:—

1. Before the commencement of a campaign, a base of supply was organised on the frontier. From the magazines at the base, the troops supplied themselves during the concentration, and replenished their mobile supplies before taking the field.

2. The mobile supplies in the train were only to be used in cases of extreme necessity.

3. During movements and military operations, the troops availed themselves of the local resources by arrangement of the intendance, whose duty it was to collect supplies from the inhabitants, and to issue them to the troops. The whole of the occupied country was divided into several intendance districts, the intendant of each district regulating the collection of supplies from the inhabitants and their delivery at the magazines or to the troops. The general control of the supply operations devolved upon a special chief, the Intendant-General of the army. The execution of requisitions by the troops themselves was only permitted in cases of necessity (such strictness was however observed more in theory than in practice).

4. As the army moved forward, *étappe* magazines were organised on the line of communications for the supply of passing detachments, and for the event of a retreat; these magazines were also filled from the local resources by requisition.

5. With the same object, in proportion as the army moved away from its original base, intermediate bases were formed.

6. When distributed over a large area, the troops were supplied by the inhabitants; when closely concentrated, from magazines.

This in its broad features is the essence of the requisition system in the time of the Napoleonic wars. But it is necessary to remark that this system was only attended with complete success when the theatre of operations was a rich and well populated country, like Italy, Germany, or Austria. In poor countries it was necessary to ground the supply of the army on the transport of stores from the base, and to have a large train. But the result of this was to retard the rapidity of the operations, particularly if the routes of communication were in an unsatisfactory condition. Napoleon in 1812 did not act thus. Foreseeing the impossibility of supplying himself by requisitions in such a country as Russia, he collected immense reserves of stores at his base, and made all arrangements for moving them, but did not take into account the necessity of subordinating the movements of his army to the rapidty of movement of his supplies. In other words, after changing his system of supply, he held to his previous method of making war. We all know how dearly he paid for his mistake.

Following the example of the French, all the other armies passed at the commencement of the century from the five-march system of supply to that of requisitions.

What is the system of supply which obtains at the present day?

In our time, the system of supply consists in the adaptation of the different methods elaborated in previous wars to the circumstances of each campaign. Consequently armies of the present day are supplied from their own resources (mobile reserve and magazines), and also live at the expense of the theatre of war (requisitions and quartering on inhabitants). Supply from one's own resources alone is only had recourse to in barren countries; to live exclusively on the resources of the theatre of war is possible only in a densely populated and rich country, with a small army, &c. In the majority of cases armies make use of both means.

Let us now see *what mobile reserves* the chief European armies have with them, when and in what order they use them, when and how they depend upon stationary

magazines, and lastly, what conditions are attached to the utilisation of the resources of the country. Afterwards, in order to clear up the question still more, as to the application of the various methods of supply in the present day, we will sketch the supply of the German armies in 1870–71.

Supplies carried with the army.—Generally speaking, an army is supplied in time of war partly from its own resources and partly from those of the theatre of war.

The supplies carried, consist of mobile and stationary reserves. The mobile reserves are classed in three categories, (*a*) knapsack reserve; (*b*) regimental train reserve, and (3) field magazines. The stationary reserves consist of the magazines formed at the base and on the theatre of operations.

Let us commence with a consideration of the mobile reserves.

The object of the mobile reserves is to guarantee an uninterrupted supply during military operations, in case of necessity. Consequently, speaking theoretically, the more abundant the reserves, the better is the supply guaranteed.

But as the army becomes more cramped in its movements in proportion as the dimensions of the mobile reserve increase, the amount of the mobile reserve must be limited to the requirements of urgent necessity. These requirements vary according to circumstances.

Hence arises a classification of the mobile reserves under two sharply defined heads—mobile reserves kept immediately with the troops, and mobile magazines.

The amount of the knapsack reserve, and of the reserve carried in the regimental train, is definitely laid down in all armies; but the extent of the reserve in the mobile magazines depends on the conditions under which the war is conducted, and consequently varies.

The cause of this difference is intelligible. We have already explained that an army must always have with it a certain proportion of reserves, no matter where the war may be carried on as, not only in the sphere of the enemy's operations but under many other circumstances, the troops have to make use of their mobile reserves, even in the most densely populated and richest country.

But in order that the mobile reserves with the army may effectually guarantee the supply, it is necessary to take steps that in the event of these reserves being expended, they may be at once replaced.

This replenishment should take place as far as possible from the resources of the theatre of war; but as these resources cannot be counted upon everywhere and under all circumstances, it is necessary to have a definite source of replenishment. This source is the mobile magazines.

Hence it becomes plain that it is necessary in all cases to have with the army mobile magazines, in order to guarantee the supply against unfavourable contingencies. The number of mobile magazines varies in every campaign with the resources of the theatre of war, the state of the routes of communication, and with all those conditions to which reference has already been made.

The resources of the country and the routes of communication play a most important *rôle*. The more quickly the reserve with the troops can be replenished from local resources, or from stationary magazines, the less the number of mobile magazines, and consequently the more free and rapid the operations.

It is evident that if the troops have a fully guaranteed communication with their base by rail or water routes, the number of mobile magazines may be reduced to a minimum, and under very favourable circumstances there need be no mobile magazines at all. And *vice versâ*, in a barren country where there is an absence of good communication with the base, the mobile magazines may grow to colossal proportions.

And thus the number of mobile magazines is determined for every given case separately, while the amount of the knapsack reserve, and the reserves carried in the train remain the same.

The proportions of these latter vary in different armies.

The knapsack reserve in Russia consists of three days' biscuit, at 1·8 lb. for each day, and a two days' reserve of salt ($\frac{1}{4}$ lb.), consequently a weight of $5\frac{1}{2}$ lbs.[1]

In the German army the soldier also carries a three days' reserve, but this reserve consists not merely of bread, or biscuit, but of several necessary requisites, viz., groats, or rice, salt, coffee, and if possible, of dripping and salt meat.

The daily ration in war consists of (*a*) $1\frac{1}{2}$ lb. bread or 1 lb. biscuit; (*b*) $\frac{3}{4}$ lb. fresh or salt meat, or $\frac{1}{3}$ lb. dripping; (*c*) $\frac{1}{4}$ lb. rice or groats; (*d*) $\frac{7}{8}$ oz. salt and $\frac{7}{8}$ oz. roasted coffee. If no meat is issued, the ration of bread is increased to 2 lbs.

Consequently the knapsack reserve of the German soldier (three days' portion) weighs 6·3 lbs., if the bread ration is in biscuit; if of baked bread, the weight is increased to 7·8 lbs.; if no meat is issued, the knapsack reserve weighs 8·55 lbs.

This reserve is called "iron ration" (*eiserner Bestand*), because it is only to be expended by order of the army corps commander.

The German knapsack reserve has the further peculiarity that its amount and even its existence are not unconditional. Whether the men have it or not is left to the discretion of the commander-in-chief; he is limited only by this, that the iron ration must not be increased beyond a three days' supply.

In the Austrian army the knapsack reserve consists of two parts, (1) the "iron ration" (*eiserner Vorrath*); and (2) the expense reserve.

The iron ration consists of a two days' ration of solid bouillon (·45 lb.), biscuit, rice, and salt; for infantry, ·68 lb., for other arms, 1·35 lb., biscuit.

The expense reserve consists of two days' bread and messing requisites.

The daily ration of the Austrian soldier consists of 1·4 lb. bread, ·45 lb. meat, ·3 lb. of ground flour or rice, groats, potatoes, &c., dripping, salt, pepper, coffee, sugar, spirits, and tobacco. All these together, exclusive of meat and spirits, which are not carried in the knapsack, weigh $2\frac{1}{4}$ lbs.

Consequently the knapsack reserve of the Austrian soldier weighs:—

1. The iron ration	1·35 lb.
2. Expense reserve..	5·00 lbs.
	6·35 lbs.

Consequently the greatest reserve of supplies is carried by the German, then by the Austrian, and lastly by the Russian soldier.

In all armies, for the most part, the knapsack reserve is only drawn upon under exceptional circumstances, with the permission of the commander-in-chief. The maintenance of the reserve in its entirety should be the first consideration of a commander, as the lower ranks do not understand the importance of the question. They often eat it up without any particular necessity, while during difficult marches they simply throw it away as a superfluous burden. Hence it is necessary to inspect the knapsacks frequently, and to punish severely any unauthorised expenditure of the reserve. A writer of some note relates that in the campaign of 1812–15 some commanders were obliged to seal up the knapsacks of the young soldiers.

Besides the knapsack reserve there is also a reserve for the horses.

In the Austrian army this reserve is also divided into an "iron" and an expense reserve. The "iron reserve" consists of a three days' ration of oats, the expense reserve of four days' ration of oats and hay.

In the German army every artillery horse carries a three days', and all other horses a one days' ration of oats alone.

In Russia each riding horse is obliged to carry a two days' ration of oats and hay, while for each draught horse a four days' reserve is carried in the train.

The reserves carried in the train also vary in different armies.

In the Russian army five days' reserve is carried (all in the regimental train); in the German army four days' (all in the corps train); in the Austrian army six days' (two days in the regimental and four days in the divisional train).

The four days' reserve of the Russian army consists only of biscuit (1·8 lb. per day per man), and groats (·22 lb.); salt and dripping for three days.

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[1] Weight of knapsack fully packed is 21 lbs. 11 oz. All the weights given are in English pounds, &c.

The German four days' reserve consists of baked bread (for two days at 1·8 lb. per man daily), biscuit (two days at 1·35 lb.); vegetables, coffee, and salt. Besides this, on taking the field they carry with them in the carts of the commissariat park (*Fuhren-park*) a six days' supply of oats and hay. When expended, this supply apparently is not replenished, as the carts are otherwise employed in bringing up supplies to the troops.

The Austrian reserve consists of six days' ration of bread or biscuit, groats, grease, salt, pepper, sugar, coffee, spirit, and tobacco; of eight days meat (seven days' live cattle and one day in carcase), one day's supply of oats and hay.

Let us now see how the different armies are guaranteed by the mobile reserves at immediate disposal in their knapsacks and in the train.

	Bread or Biscuit.	Meat.	Messing Requisites.	Forage.	
				Oats.	Hay.
Russian Army	8 days	..	Salt 5 days Dripping 3 days	2 days for riding horses. 4 „ „ draught.	
German Army	7 days	Sometimes not more than 3 days	7 days	7 days	6 days, but only at first.
Austrian Army (excluding "iron reserve")	8 days	8 days	8 days	1 day.	

Consequently, as regards number of days for which reserves are carried, the German army is least well provided. The Russian and Austrian armies have a reserve for the same number of days, but the reserve in the Austrian army is much more liberal than with the Russians. Generally, in point of completeness, the Austrian mobile reserves occupy the first place; at the same time the size of the commissariat train in the Austrian army is greater than in the Russian or German.

Let us now proceed to the consideration of the second category of mobile reserves —the mobile magazines.

We have already mentioned that the object of the mobile magazines is to serve as a commissariat reserve in the event of its being impossible to draw upon stationary magazines, or to make use of the resources of the country. It has also been stated that the number of these magazines will depend chiefly on the resources of the theatre of war, and the state of the roads. Thus, for example, in the last expedition to Khiva, the field magazines consisted of 8,800 camels, and the entire reserve was for two and a-half months for the 5,500 men of the Turkestan detachment; during our wars with Turkey, the field magazines carried a month's, and even two months' reserve; during the American War, the Federal armies had with them field magazines with a twelve or fifteen days' supply as a rule; in the Crimean War, in 1854, there was with the Danube army of Prince Gortschakoff (100,000 men), a field magazine of 13,000 carts, with one month's reserve; during the Hungarian War, in 1849, our army had a field magazine with a ten days' reserve. The Austrian army, during the campaign of 1866, was dependent upon its field magazine with its six or eight days' reserve. The German army, in 1870-71, had no field magazines at all.

The field magazine may consist of a Government or of a hired train.

A special Government train for forming the field magazine does not exist in any army, it would be too dear and troublesome. Moreover, it is never known when and of what dimensions the magazine is required, and consequently there is no normal to guide the quantity of carts to be held in reserve. Hence the field magazine is always

formed as required, of country carts, either by impressment, according to a fixed tariff, or by hiring.

Let us now examine the arrangements in different armies for forming the field magazines generally, and what proportion of commissariat stores they should carry.

First, let us remark that the field magazines are very seldom distributed among the troops; *i.e.*, equally by corps or divisions, but for the most part form an appurtenance to the whole army.[1] The reason is intelligible; as they form the commissariat reserve of the army, they must be at the exclusive disposal of the commander-in-chief.

In our army, the functions of the field magazine belong to the so called *intendance transport;* in the German army, each corps has a special commissariat park (*Fuhren-park*) divided into five columns, while in the Austrian army, there are field commissariat magazines (*Feldverpflegs-magazin*). These variously denominated field magazines are formed in all three armies of country carts, but differ in organisation and in the stores they carry.

Our intendance transport has the further peculiarity that its functions are not limited to the *rôle* of a field magazine. It is intended not merely for carrying commissariat, but other kinds of stores, while at the same time it is available for the transport of sick and wounded; lastly, the transport sections may be distributed at the *étappe* points for the conveyance of baggage and sick from one *étappe* to another. In a word, our intendance transport has to meet all demands on transport in time of war.

In consequence of this, its dimensions cannot be rigidly laid down. The amount of transport must correspond in each given case to the demands upon it. The only condition is that the transport should not be divided into larger sections than 350 pair-horse carts in each. As regards the quantity of commissariat stores carried, the normal may be taken as a ten days' supply. Of course the normal is not unconditional, it may happen that the supply to be carried may be twice or thrice as much, or again it may be only one half as great. Sometimes it may be unnecessary to have an intendance transport at all.

In any case, it will be instructive to consider, (1) the number of men and horses for which one section of the intendance transport can carry a ten days' supply, (2) the number of sections requisite for an army of 300,000 men and 50,000 horses.

For this purpose it is necessary to know the carrying power of each cart. As the transport is formed of native carts and horses, it follows that the carrying power of these will vary with the capacity and strength of the carts, and the power of the horses or oxen of the country where the transport is formed. As an approximate calculation, we may assume that a pair-horse cart will not carry more than half a ton.

In laying down the limiting weight, it is necessary to take a moderate figure, as every cart has to carry forage for its own horses.

A ten days' supply for one man (five days' bread, five days' biscuit, ten days' groats, salt, and dripping), weighs in all 25·7 lbs.; a ten days' supply of oats for one horse weighs 108·36 lbs. Consequently a cart with half a ton load may take, in round numbers, a ten days' supply for 40 men or 10 horses. Therefore a section of intendance transport of 350 carts, will carry a ten days' supply for 14,000 men or 3,500 horses.

But as 14,000 men is approximately the strength of an infantry division with its artillery park and field hospital, a section of intendance transport may be taken as the basis of calculation for each division.

On this basis an army of 300,000 men and 50,000 horses will require for its 10 days' supply—

300,000 men—7,500 carts and 15,000 horses, *i.e.*, 22 sections (Nos. 1-21 of 350 carts, No. 22 of 150).

50,000 horses—5,000 carts and 10,000 horses, *i.e.*, 15 sections (Nos. 1-14 of 350 carts, No. 15 of 100).

making a total of 12,500 carts and 25,000 horses (37 transport sections).

[1] In the German army, they are distributed equally to the army corps.

In the German army, the number and size of the transport parks is definitely laid down. Each army corps is allowed one park of 400 pair-horse carts; each park is divided into five columns of 80 carts each.

In the Austrian mobile magazines, a twelve days' supply of provisions and oats is supposed to be carried for all the men and horses of the field army. It is at the same time laid down that the number of magazines is calculated so that each of them should carry a twelve days' supply for not more than 50,000 men and 8,000 horses. Each magazine consists of, (1) a commissariat magazine; (2) horned-cattle depôt (*Schlacht-vieh depôt*), and (3) field bakery (*Feldbäckerei*); with it, besides the drivers, there are train soldiers for looking after the magazines. The guard for each magazine consists ordinarily of a company of infantry and a half-squadron of cavalry. Each magazine is so organised that it can be divided if necessary into three independent sections.

The supply carried in the mobile magazine consists of the same products which are carried in the commissariat train with the troops; it is also laid down that the bread carried should only be for six days, biscuit being issued for the remaining six days.

Besides the twelve-days' supply, the mobile magazines have to carry a four-days' supply of dry bouillon (*Fleischgries*) for replenishing the knapsack "iron" reserve.

The number of carts to a magazine varies. According to the Austrian regulations, a pair-horse country cart carries 5 centners (612 lbs.) in Gallicia, the Bukowina, Istria or Dalmatia, and 10 centners (1,224 lbs.) in the other provinces. The burden of a pack animal is 2½ centners (306 lbs.)

Let us now pass to the consideration of the second method of supply—*from magazines.*

In speaking of the conditions of supply generally, we have already alluded to those cases where troops receive their food from magazines. As a general rule we should only have recourse to this nature of supply where it is impossible to utilize the resources of the country.

But during the concentration of troops at the commencement of the war, in the siege and defence of fortresses, in defensive operations and when retiring in one's own country, during the suspension of military operations, and during an armistice, we nearly always have to employ this mode of supply. It is particularly indispensable when very large forces are concentrated under the above circumstances in a small area or remain for a long time in one and the same place.

Consequently in our time, the magazine system, although it has ceased to be the chief, nevertheless retains great importance. Let us now examine it in detail.

Magazines are (*a*) internal and external, according to their position; (*b*) reserve or main, intermediate and expense, according to their destination. The first are established at the primary base, the second at the intermediate base, and the third in the immediate neighbourhood of the troops.

Reserve or main magazines are of two kinds; the one exists, in time of peace, in the frontier districts at those centres indicated beforehand as the points of concentration of troops in time of war; such for example are our magazines in some of the frontier fortresses, where an intangible store of flour, groats, and oats is permanently maintained; this store is kept fresh by using up the last year's supply during the current year. Other reserve magazines are established before the campaign or during its continuation, at those points near which the troops are concentrated, or from which stores can be conveniently and quickly conveyed to the army.

Intermediate magazines are formed during offensive movements, when the army proceeds so far from its primary base that it becomes necessary to establish an intermediate one. They differ from the reserve magazines in being filled by requisitions.

Expense magazines are intended for the current supply of the troops, and hence are established at any time before or during the war, according as they may be required. They have a temporary character, existing only for a few days, and sometimes for only one day. Among expense magazines are also included the *étappe* magazines on the lines of communication, for the supply of passing detachments and of the troops garrisoning the *étappe* points.

From these definitions it is plain that the magazines vary in their organisation

according to the functions which they have to fulfil. The selection of sites, their number, size, the amount of reserves to be accumulated in them, the time of opening, the means for their replenishment will depend on the *rôle* each magazine has to play, whether it be reserve, intermediate, or expense.

Measures for the Supply of Troops in time in War.

We have already said that the magazine system is unavoidable at the commencement of a campaign when the troops are in process of concentration on the frontier, and at the earliest stage of the war before taking the offensive or commencing a retrograde movement. Consequently the arrangements for provisioning the army ordinarily commence with measures for its supply from magazines.

As a general rule, this task may be divided into two parts, (1) supply up to the commencement of military operations, (2) supply during military operations.

Let us now see how the first task is solved.—*Supply before the commencement of military operations.*

In the same way that it is impossible to commence military operations without preparing a preliminary plan, so, in order to ensure the supply, it is necessary to consider beforehand how this latter can be best accomplished.

The following points must be attentively studied.

1. What quantity of stores is necessary for a given army daily, and for how many days must they be collected?
2. Where must they be collected?
3. When must they be collected at the selected points?
4. Whence are the stores to be obtained?
5. By what means are they to be delivered at the selected points?
6. What time is required for the transport to these points; and, in connection with this, when must the transport be commenced so that it may be completed on the appointed date?
7 What number of bakeries is required at the magazines; where are they to be built; and by what date?
8. What arrangements for the demand and issue should be fixed?
9. In what way should the expended stores be replenished?
10. Where and when should the mobile magazines be collected?

After these questions others would arise, which have also reference to the second part of the task, the supply during military operations.

Let us take these questions in order.

The daily wants of the army are calculated according to the rations of food and forage.

Thus for example, an army of 300,000 men with 50,000 horses will require daily—

1. Flour, by weight	..	2 lbs.	×	300,000	=	268 tons.
,, measure	..	1·443 qts.	×	300,000	=	13,528 bushels.
2. Groats, by weight	..	·301 lbs.	×	300,000	=	40 tons.
,, measure	..	·192 qts.	×	300,000	=	1,800 bushels.

3. Meat in live cattle, at the rate of ·451 lbs. per day, would be, for 300,000 men—135,300 lbs. Calculating that each head of cattle furnishes 360 lbs., it will be necessary to slaughter 375 oxen daily. But if the meat ration be doubled, as has been the case in previous campaigns, the army of 300,000 men will require 750 oxen daily.

4. Oats, by weight..	10·836 lbs.	× 50,000 =	540,000 lbs., or 241 tons.
,, measure..	8·661 qts.	× 50,000 =	13,530 bushels.
Hay, by weight..	9·03 lbs.	× 50,000 =	450,000 lbs., or 200 tons.

After determining the daily requirements of the army it is necessary to fix the number of days for which the stores are to be prepared (except hay, which is only stored under special circumstances, and meat, which is generally purchased by the troops themselves) in the magazines at the base. This will depend in each case upon a balance of all the conditions which influence the supply of armies in time of war, and mainly on the state of the line of communications.

As a general rule the amount of stores at the primary base may be assumed at a

month's reserve (if the theatre of war be rich, thickly populated, and intersected by a sufficient number of good roads of communication), and this would be after deduction of the amount necessary for the mobile magazine. But as ordinarily not only the mobile magazine, but the mobile reserves with the troops are completed before the commencement of military operations from the magazines at the base, the normal amount of reserves in these magazines should consist of a supply for one and a half to two months.

Under unfavourable circumstances this amount of course must be greater. Thus for example, if the troops have to operate in a poorly populated country with bad roads, a three or four months' supply must be collected in the magazines at the base; when operating in desert countries, the amount might be a six months' supply, and even more.

For the garrisons of fortresses, a six months' provision should be stored. In this case it is as well to bear in mind that in the event of a siege we may have to assist the population, which will be unable of itself to prepare the necessary supply for this eventuality.

For example, let us suppose an army of 300,000 men (with 50,000 horses) ordered to take the offensive from Poland into Posen and Prussian Silesia. This army will be based on the Vistula.

Let us further assume that it is determined to collect in the magazines at the base, a one and a half month's supply of flour, groats, and oats, and in addition, to form an intendance transport with a ten days' supply of biscuit, groats, and oats.

This makes—

1. For the magazines	Flour	12,290	tons weight.
" "	Groats,	1,808	"
" "	Oats,	10,842	"
2. For the intendance transport..	Biscuit,	2,410	"
" " " ..	Groats,	402	"
" " " ..	Oats,	2,410	"

Let us now pass to the second question. Where must the stores be collected at the base?

The selection of supply depôts depends upon the geographical position and their strategical importance. The two main conditions which these points must satisfy are the following: immunity from seizure by the enemy, good and rapid communication with the army.

Consequently it is more convenient to establish the magazines in fortresses and fortified camps, as these points, while safe from the enemy, are at the junction of the main roads, in positions favourable in a geographical and important in a strategical sense.

The number of magazines at the base will depend on its extent and on the size of the army. In any case this number must not be too limited; a small number of large magazines may be better secured from the enemy; on the other hand, the less the number of magazines, the greater the difficulties of supplying the army from them. We must bear in mind that the great defect in the magazine system is the difficulty of carrying supplies from the magazines to the army, a defect which cramps the freedom of an army's operations. It is perfectly clear that the more limited the number of magazines, the slower is the delivery of supplies to the troops. The collection of a large number of country carts is difficult and requires much time, as the greater the number of carts, the more extensive the *rayon* from which they have to be collected. On the other hand, when the number of magazines is large, the army taking the offensive has greater freedom of operations, as the transport to the front proceeds more quickly, while in the event of retreat, the contents can be more easily removed.

A negative example of this may be seen in the war of 1866. The 13 mobile magazines of the Austrian army (2,000 carts in all) had at one time to load from two magazines, at Josephstadt and Königgratz. In consequence of this the roads were completely blocked, the mobile magazines crossed on the line of march. To load one mobile magazine demanded from eight to ten hours, so that the whole of the 13 magazines could not be filled under five days, working day and night.

From this it is evident that the number of magazines at the base must be determined by the facilities for using them. But as this number further depends upon other considerations, it becomes impossible to fix a standard for the quantity of supplies to be maintained in each magazine. But it may be stated approximately that if the number of the magazines be calculated upon the basis that each provides a monthly supply for 40,000 to 50,000 men, this figure will be found a convenient proportion.

Consequently if in our example we limit the magazine to a month's supply for 50,000 men, we should have to form nine magazines at the base. The size of the magazines of course cannot always be the same in practice; at some points we should have to collect more, at others less stores. The difference in size would be conditional upon the greater or less number of troops, the comparative extent to which each magazine was guaranteed from seizure, the number and convenience of the roads of communication, and so forth. The practical condition which, among others, must be fulfilled by magazines, is that all mobile magazines which have to be replenished from them, may be laden and despatched within twenty-four hours.

All that we have said with regard to the selection of points and the number of magazines, refers only to the main and intermediate magazines. The number of *étappe* magazines is regulated by the number of lines of communication and their length, because an *étappe* magazine must be established at each halting place. Of course if a railroad forms the line of communication, the number of *étappe* points, and therefore the number of *étappe* magazines, is much diminished. The dimensions of the *étappe* magazines are various, and depend on the average strength of the passing detachments.

As regards *expense* magazines, their number and size cannot be determined by rule even approximately. With reference to the selection of points for these magazines, it is necessary to bear in mind that rapidity of replenishment and delivery is of paramount necessity. The quantity of supplies in expense magazines must be strictly limited to the amount which may be actually expended. It would be both costly and difficult to transfer stores from one expense magazine to another.

Let us now pass to the consideration of the question in what time could the supplies be collected in the magazines at the base?

The demand for food arises at the very commencement of the troops concentrating, and increases daily as the troops are drawn together from all quarters. Consequently, from this cause alone, magazines at the base must contain a certain quantity of supplies *before the army commences its concentration.*

But besides these, there exist other no less serious reasons why magazines at the base should be open sooner than the troops commence their concentration. Firstly, the army must concentrate as rapidly as possible. To this end, all the lines of communication must be kept almost exclusively for the movement of troops and their baggage; consequently it becomes impossible to move provisions and forage at this time. Secondly, immediately after the concentration of the troops, the military operations ordinarily commence, and up to the time of their commencement all the slow and cumbrous supply-mechanism must be already set in motion, otherwise the wants of the army will not be insured. Lastly, in the third place, the magazines at the base in the majority of cases affect the supply-service in all the subsequent periods of the campaign, and therefore the sooner they are opened, and the better they are organised, so much the more favourable. Magazines at the base serve for the first equipment of the mobile reserves with the troops, should circumstances not allow them to take the field with a full supply, or they be forced to expend it during their march to the points of concentration. Secondly, from the magazines at the base are often replenished the *étappe* and expense magazines, which are opened in the *rayon* of the concentration of the army, as sometimes these magazines cannot be replenished from the resources of the country, nor by direct delivery from contractors or agents. Thirdly, the magazines at the base serve also during the operations for replenishing the mobile reserves, and for filling those expense magazines which are established within the sphere of military operations. For these objects the magazines at the base serve, however, only in case of extreme necessity, as the stores have to be moved, and we have already said more than once, recourse should never be had to the slow and costly operation of moving stores except when the supply cannot be guaranteed by other means.

From what has been stated, it is plain that—

1. Magazines at the base must be established as soon as possible.
2. As there is hardly a possibility of collecting in time the pre-determined quantity of stores in these magazines, part must in any case be accumulated before the concentration of the troops. The rest must be collected in part while the troops are concentrating, and part when that is finished.

What quantity should be collected in the magazine at the base before the troops commence to concentrate, it is difficult to define. It entirely depends on the length of time available for preparing for war, and secondly, on the number and state of the roads, and the transport available for conveying the stores to the magazines. We can only state the quantity which it would be *desirable* to have in readiness at the base before the concentration of the troops.

The quantity should be sufficient (1) to supply the troops for the whole time until concentration, (2) to complete the mobile magazine of the army. The mobile reserves with the troops should be replenished by them at the points of mobilisation, and should not be expended without the special order of the commander-in-chief; consequently, strictly speaking, these reserves must up to the time of the completed concentration of the troops remain untouched by them. But as we have already said, it may happen that these reserves will have also to be filled from the magazines at the base.

Assuming that two weeks are required for concentration after the declaration of war, and that the normal of the stores in the mobile magazine is a ten days' supply, as laid down for our intendance transport, it follows that *it is desirable to have a twenty-four days' supply ready in the magazines at the base before the commencement of the concentration.*

Consequently, for an army of 300,000 men with 50,000 horses, it is desirable to have in the magazines at this period—

Flour..	324,880	quarters.
Groats	43,240	„
Oats	324,880	„

The next question is, whence are stores to be obtained for filling the magazines at the base?

To give a direct answer to this question is of course impossible. Those means are the best by which the magazines are filled the quickest and the most perfectly; cheapness is a secondary consideration.

One thing is perfectly clear, that transport from a distance should as far as possible be avoided, as (1) it demands much time, (2) is expensive, and (3) swallows up a mass of transport.

But in practice it frequently happens that the magazines at the base have to be filled from distant parts.

Hence it is necessary to have an idea how the supplies are conveyed to the base, and how much time is necessary for the purpose.

At the present day, in European warfare, when armies are concentrating towards the frontiers, ordinary roads are only used for third-rate purposes. The chief means of transport for troops and stores are railways. Hence it is necessary in the first place to become acquainted with their capabilities for the transport of stores.

The employment of railroads for these objects is divided into two main periods:—

1. The collection of stores in the magazines, *prior to the movement* of the troops.
2. The transport of stores to the base, and thence to the army, after the conclusion of its concentration, when military operations have already begun.

During concentration the railroads can only be used for supplies to a very limited extent. Thus for example in 1859, during the movement of the Austrian troops to Italy, of the 12 military trains which left Vienna daily, only one, or at the most two, were reserved for supplies. The same arrangement was observed in 1866, when the Austrian army concentrated round Olmutz.

With these examples before us, we will repeat once more that it is of the highest importance that the magazines within the *rayon* of concentration of the troops should be filled before the troops commence to draw together; and as in the present day rapidity of mobilisation and concentration have acquired such importance, that all Govern-

ments will use their utmost endeavours to place their troops on the frontier in the shortest interval after the declaration of war, the time for the preliminary transport by rail will be very short. Consequently, in order to guarantee the wants of the troops during concentration and preliminary operations, we shall probably in the future have to organise our base of supply, not on the declaration of war, but when it is threatening. Of course this will sometimes entail unnecessary expense on the treasury, but the supply of the army will be guaranteed. In proof of this, we may instance the war of 1870. Everybody knows with what unprecedented rapidity the German army was concentrated on the French frontier, but all do not know that this army suffered at first from insufficiency of supplies, in spite of the wealth of the theatre of operations, and the extensive system of requisitions. This occurred because there was no time for the collection and transport of supplies, while during the concentration, the railways could not be used for stores. Moreover, for such immense forces as the German, the resources of that small *rayon* in which these forces were concentrated were not adequate.

It may be urged that the collection of supplies at the base when war is threatening, enables the enemy to detect the plan of operations, or at any rate, the *rayon* in which the troops will be concentrated. This is true. But to meet this the same tactics must be employed as for crossing a river in face of an enemy; demonstrations of forming magazines must be made at those points where there is no intention of operating. Of course these demonstrations will cost money, but war cannot be made without sacrifices, and certainty of supply is so important that we must make every effort to ensure it. Moreover, the stores collected for demonstrations may be used subsequently after the campaign has commenced.

Thus we have shown, that part of the supplies must be collected at the base before the troops commence to move, and that the most important means of communication, railroads, can only be used for the transport of stores prior to the concentration of the troops or after this concentration is completed.

The next question is, how much time is necessary to bring supplies by rail to the base? that is to say, for example, how much time is required to bring twenty-four days' food for a given army from the points where it is delivered to the depôts at the base. We will endeavour to illustrate this by an example.

Let us return to our original assumption. Suppose that a war being imminent with Prussia, it is resolved to concentrate in front of Warsaw an army of 300,000 men, and 50,000 horses, with the object of invading Prussian Silesia and Posen. The base of this army will be Poland, behind the Vistula. The points for the formation of magazines are Bialystock, Brest, Novo-Georgievsk, Warsaw, Ivangorod, Novaya-Alexandria Kutno, Skernevitse, and Lodz.

Let us further suppose, that it is resolved to distribute the supplies as follows:—

In Bialystock and Brest	7 days in each,	thus	14 days.
,, Warsaw, Novo-Georgievsk.. ..	10 ,,	,,	20 ,,
,, Novaya-Alexandria and Ivangorod	5 ,,	,,	10 ,,
,, Kutno and Lodz	4 ,,	,,	8 ,,
,, Skernevitse..	8 ,,	,,	8 ,,
	Total ..		60 ,,

In the first period, before the concentration of the troops, we shall limit ourselves to filling the magazines in Warsaw, Kutno, Skernevitse, and Lodz, *i.e.*, the transport of twenty-six days' supply. Let us suppose that there are ten days' supply in Warsaw; this is actually the case, as there is in that city an intangible reserve of 260,000 bushels of grain, with a proportion of groats and a corresponding reserve of oats. Consequently we have only to calculate how much time is required for the transport of stores to Kutno, Skernevitse, and Lodz, *i.e.*, for the transport of sixteen days' reserve for 300,000 men and 50,000 horses.

Let us assume that the supply is brought half from Moscow, half from Riga; consequently by two railways to Warsaw, thence to Skernevitse by one, and afterwards by two.

As the transport of stores must be effected before the commencement of the concentration, and even before the declaration of war, it is impossible to stop the passenger

and ordinary goods trains. Consequently it is necessary to consider what number of trains can be calculated upon without interfering with the ordinary traffic.

We will assume as a general rule, that by our single-line railroads it is possible to despatch ten military trains in twenty-four hours when the ordinary traffic is entirely stopped.

Consequently if this traffic is not stopped, we may probably count upon three trains in the twenty-four hours. We will proceed on this supposition. Hence by two lines of rail six trains may come to Warsaw daily.

A goods train consists ordinarily of 25 to 30 waggons, and as each waggon holds 6¼ to 7¼ tons, a train will convey on an average 190 tons.

The daily supplies for 300,000 men and 50,000 horses weigh—

Flour	277	tons.
Groats	40	„
Oats	240	„
Total ..	557	„

Consequently for the daily supply of that number of men and horses, three trains will be necessary. But as this is the number which can be sent daily, it follows that by the two lines of rail to Warsaw two days' supply can be forwarded each day. Hence for the transport of sixteen days' provisions, 48 trains must be run, or twenty-four by each railroad. Therefore from Moscow and Riga three trains must be sent daily for eight days.

But this does not mean that the whole sixteen days' supply will be brought to Warsaw in eight days. Goods trains move slowly; they travel on an average 10 miles per hour, so that each train will be about four days on the road from Moscow or Riga to Warsaw. Consequently the last train sent from those places on the eighth day will not arrive in Warsaw before twelve days, counting from the day of the movement commencing.

In Warsaw there is no branch railway between the St. Petersburgh and the Warsaw-Vienna termini, as the stations are separated by the river Vistula,[1] and there is only a single bridge for ordinary traffic. Consequently all trains on arrival at Warsaw must discharge into carts, which are then taken to the other station, and their contents again shifted to other waggons. It will be instructive to calculate the time and amount of transport required for this.

Each train carries 190 tons. There will be six trains in the day at intervals of four hours.

For 190 tons, about 240 two-horse carts will be required, allowing 16 cwt. each. In order to load these 240 carts simultaneously (which, however, is impossible, from want of siding) we must allow eight men to each. Consequently 1,920 men will be required. If we divide the transport into two sections, so that the first section is completed first and despatched, and the other afterwards, the number of men may be diminished by one half, while the time will be, if not doubled, considerably lengthened. In any case the unloading and shifting to the carts will occupy not less than two hours, supposing perfect order is maintained and that the men are told off to the carts beforehand. The transit from station to station will occupy at least one hour. The unloading and shifting to the waggons at the Warsaw-Vienna railway will occupy two or three hours. Consequently the same lot of carts cannot return to the St. Petersburgh station in time for the next train, and therefore two cart trains of 240 each will be required. Thus each train of carts will be laden and unladen three times in the twenty-four hours; for the work about 1,000 men will be required each time. As the same men cannot work for twenty-four hours on a stretch, three reliefs will be necessary, or 3,000 men in all.

From Warsaw to Skernevitse, Kutno and Lodz is only a few hours, so that it may be calculated that on the day after arrival at Warsaw, the stores will be delivered at these places. The process of unloading and delivery at the magazines will take

[1] Since this was written, through communication has been made by a railway bridge over the Vistula.—*Translator.*

the same time as the transit between stations at Warsaw, and, if previously arranged, this can be done on the day of arrival.

Consequently, the sixteen days' supply can be delivered at the magazines on the fourteenth day[1] after leaving Riga and Moscow, *i.e.*, their transport should be taken in hand a fortnight before the troops commence to concentrate.

From this approximate calculation, the length of time necessary for the transport of supplies will have been seen. Were this transport to commence at the same time as the troops begin to concentrate, it would be impossible to allow more than one train on each railroad in the twenty-four hours. Consequently the sixteen days' supply could not be delivered at the magazines under forty-two days. And as in the present day the idea could not be for a moment entertained of delaying the opening of the campaign for forty-two days, it is evident that at the very least one-half of this supply must be on the spot before it is required.

Let us now consider the amount of supplies which can be transported daily by rail during the second period, *i.e.*, after the concentration of the troops.

When the troops have concentrated and the military operations have commenced, the railroads in rear are used almost exclusively for the transport of commissariat and other stores, and for the removal of the sick from the army.

The greater part of the transports are taken up with commissariat stores. If we allow eight trains a-day for this class of stores, then on each day we may throw into the magazines at the base, a three days' supply for an army of 300,000 men and 50,000 horses. But as for a day's supply of this number of men three trains are requisite, 90 trains, or eleven days, will be necessary to deliver a month's supply.

If we have to send cattle by rail, it will be necessary to remember that not more than seven or at the most eight head can be placed in each waggon. A train of 30 cattle waggons will take 240 head. Assuming that each head of cattle furnishes 360 lbs. of meat, and also that the men are to have a double ration, *i.e.*, ·9 lb. of meat per diem for each man, it follows that each train will carry the meat for 96,000 men. Consequently the daily ration of meat for 300,000 men, requiring 750 head of cattle, can be carried in three trains. If therefore we wish to forward 6,000 head in order to supply the force for the same number of days, as they have biscuit and groats in their knapsacks and in the regimental transport, *i.e.*, for eight days, we should require 25 trains. Hence three days would be required, calculating eight or nine trains per day.

We now have to consider another very important supply question—the baking of bread and biscuit in time of war.

Corn is delivered at the magazines in the shape of meal (sometimes in grain), at any rate when they are first filled up, before the concentration of the army. Should it be delivered as bread, much more transport would be required in the first place, as bread is at least 25 per cent., and ordinarily 35 per cent., heavier than flour; and secondly, before it could be issued it would be as hard as stone.

In consequence of this we have to bake the flour into bread or biscuit in special ovens, which have to be constructed at the magazines themselves.

By the time the army is concentrated, the bread or biscuit must be ready. But in order to ensure this, it is necessary that every magazine should be provided with a sufficiency of bakers and ovens, so that they should be in operation before the army concentrates.

Hence a whole series of new questions—

1. What quantity of bread or biscuit must be baked daily at the magazines?
2. What quantity can be baked in each oven daily, and how many bakeries are required for the purpose?
3. Whence are the bakers to be obtained?
4. How many ovens are required for all the magazines at the base generally, and for each in particular?
5. How much time, and what number of labourers, are necessary to construct these ovens?

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[1] On the 13th day, now that there is no railway break at Warsaw.—*Translator.*

6. When should their building commence, so that they may be ready by a certain date?

Let us consider these questions in order.

It is necessary to be in a position to bake daily at least three days' rations. What number of ovens is required?

In the first place, bread baking in the field is chiefly done in field ovens, as it is very inconvenient to have it baked in the local ovens, for in the majority of cases their number is insufficient. In former wars, our troops not only themselves baked bread and biscuit in the local ovens, but even placed the baking in the hands of the local inhabitants.

This was the case in the Crimea. But this arrangement, although permissible under circumstances of necessity, must be regarded as abnormal. The regular means is by military bakers in field ovens.

Field ovens are of brick, unbaked brick, wattle and dab, or of earth. In a baked brick oven, 9 ft. 3 in. long, 7 ft. broad and 20 inches in height, 320 lbs. of flour can be baked into bread at one time, which will yield about 432 lbs. of bread, or three days' supply for 53 men. In an earthen oven 4 ft. 6 in. long, 3 ft. 6 in. broad, we may bake 90 lbs. flour at one time, and this yields 121 lbs. of bread, or a three days' supply for 15 men.

In twenty-four hours there may be five heats,[1] and consequently each brick oven can furnish about 2,160 lbs. bread, or a three days' supply for 265 men.

Each earthen oven bakes about 594 lbs. of bread, or a three days' supply for 75 men.

Consequently to turn out daily for an army of 300,000 men a three days' supply of bread, it will be necessary to have 1,132 brick or 4,000 earthen ovens.

Biscuit is prepared in the same ovens, but the preparation takes three times as long, as the ovens will only contain half as much sliced bread[2] as flour; moreover, to turn the bread into biscuit takes longer than the conversion of flour into bread, *i.e.*, in ovens which furnish daily 2,160 lbs. of bread, not more than 720 lbs. of biscuit can be prepared. But as the men receive only 1·8 lb. biscuit, each brick oven can furnish daily a three days' supply for 134 men.

From this it is plain that for the daily preparation of biscuit in the quantity we have assumed as necessary, twice the number of ovens is required.

But as the number is already very great, it will be more convenient to provide the army partly with biscuit, preparing it every other day. Thus on one day we shall have prepared a three days' supply of bread, on the second and third day one and a half day's supply of biscuit, and on the fourth day a three days' supply of bread, and so on. Consequently every three days we shall bake a six days' supply.

In order that the baking may be uninterrupted, we must have four bakers and two labourers to each brick oven, and two bakers and two labourers to each earthen oven.

Consequently for 1,132 brick ovens, we require 4,528 bakers and 2,264 labourers; while for 4,000 earthen ovens we need 8,000 bakers and 8,000 labourers. From this it is plain that it is more advantageous to build brick ovens of large size.

The *personnel*, however, does not end with the bakers. We require, in the first place, officers, non-commissioned officers, and men, to look after the interior economy, and also to keep the accounts; secondly, special labourers are required for bringing wood, water, and provisions; thirdly, receivers from the troops to fetch the bread.

The number of officers, non-commissioned officers, and men, is determined by the number of bakery detachments to each separate magazine. The number of labourers is calculated according to the number of ovens, allowing six men to each; lastly, the number of receivers depends on the number of units of troops supplied from the magazine.

In our army the so-called administrative troops, from which the bakery detachments are formed, do not exist; hence to provide these detachments we must take

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[1] The oven takes two hours to heat for each baking; for the baking two-and-a half hours more; consequently not more than five heats in the twenty-four hours.

[2] The biscuit of the Russian soldier consists of desiccated bread.—*Translator.*

bakers from the troops[1] (not more than four from each company, squadron, or battery), and the remaining men direct from the Reserve.

The number of ovens and of bakery detachments with each separate magazine, corresponds with the number of men ordered to use the magazine. To explain this, let us turn to our example.

We will assume that for our army of 300,000 men, concentrated in front of Warsaw for operations against Prussia, magazines will be established in Bielystock, Brest, Novo-Georgievsk, Ivangorod, Novaya-Alexandria, Kutno, Lodz, and Skernevitse. Let us assume that the baking at first cannot be done in the Bielystock and Brest magazines, while at the remaining magazines the following are the arrangements:—

In Novo-Georgievsk, Warsaw, and Skernevitse, will be baked daily a three days' supply of bread for 60,000 men at each magazine.

In Kutno, Lodz, Ivangorod, and Novaya-Alexandria, a three days' supply daily for 30,000 men at each magazine.

Consequently the following will be the establishment at each magazine:—

	Ovens.	Bakers.	Labourers.
Warsaw	227	908	454
Novo-Georgievsk	227	908	454
Skernevitse..	227	908	454
Kutno	113	452	226
Lodz	113	452	226
Ivangorod	113	452	226
Novaya-Alexandria ..	113	452	226
Total	1,133	4,532	2,266

In Warsaw of course there is no necessity to form field ovens, as, in the first place, there is a central bakery in the city; and secondly, the bread may be baked in the barracks and private ovens. In all the other towns a considerable number of ovens will be found to hand. But the number of men necessary for baking will in any case remain unchanged. Let us now endeavour to determine the number of men necessary for baking duties with each separate magazine.

For each oven six labourers are necessary for bringing up wood, water, and meal; consequently we shall require at each of the three first magazines 1,362 men; at each of the other four 678 men. Thus with each of the first three magazines there must be a bakery detachment of 2,724 men; with each of the other four 1,356. In all with the seven magazines 13,596 men, exclusive of the *personnel* for the administration of the detachments.

The organisation of the detachments must be such that all the men of one and the same body of troops should be under the superintendence of their own non-commissioned officers and officers; only under this condition is it possible to maintain discipline. Thus for example, the bakers of each infantry detachment, of each rifle brigade or cavalry division, together with the labourers appointed to assist

[1] From each infantry regiment we may take 60, from each cavalry regiment, or separate battalion 16, and from each battery four bakers. Hence we get our 4,568 bakers as follows:—

From 15 infantry divisions..	3,600 men.
„ 3 rifle brigades	128 „
„ 15 artillery brigades	360 „
„ 5 cavalry divisions	480 „
Total	4,568 „

(taken from among the reservists), must form a separate detachment under the command of their own officers and non-commissioned officers. All the detachments of one and the same division, and of one and the same army corps, must have a chief in common. Lastly, if there are detachments of different corps at the same magazine, all must be subject to one commander in common.

In order to finish the question of baking, we have only to throw light upon the time necessary to build the ovens, and to consider when their building should be commenced.

A brick oven requires for its construction five stove-setters, eight labourers, and four hours' time; the oven will take not less than six hours to dry. Consequently the same stove-setters and labourers cannot construct in a day more than three brick ovens. Hence if it be desired to construct all the 1,132 ovens in one day, we should require for the purpose, 1,885 stove-setters, and 3,016 labourers. We might possibly be able to collect that number of labourers, but it would be scarcely possible to get that number of stove-setters. Hence it will be better to allow not less than a week to construct the 1,132 ovens.

In conclusion, a few words on magazine ovens. These ovens are only found in the German army, and are made of iron. In that army two ovens are allowed to each corps; they are carried in the commissariat train, and have a detachment, consisting of one official, two non-commissioned officers, one rank and file, 14 train soldiers, and 100 bakers, stove-setters, and other artificers. The setting up of the ovens takes six hours; in twenty-four hours both ovens together will furnish a day's supply for 8,000 men, so that a day's supply for the whole corps cannot be baked under five days. From this it is plain that these ovens are merely subsidiary, and cannot do away with the construction of a considerable number of field ovens.

In the Austrian army there are no magazine ovens, but with the mobile magazines is carried the material for field ovens. With each magazine, as we have already said, there is a field bakery, with materials for 20 field ovens, and detachments of stove-setters, bakers, &c. These 20 ovens are able to bake in the twenty-four hours a day's supply for 54,000 to 60,000 men. The field bakery is organised, so that it can be divided into five independent sections, each of which can form four ovens.

Consequently the Austrian army has with it much more means for baking than the German army; on the other hand, the German magazine ovens may be ready in six hours, but to construct 20 ovens from the materials carried in the Austrian field magazine, two weeks are required. With such delay it becomes a question whether it is worth while to carry the materials for constructing ovens, as they can be obtained everywhere.

Thus we have investigated all the most important questions which have to be considered beforehand in the plan of supply. It gives us at the same time an idea of the mechanism of supply in the first period of the campaign up to the commencement of military operations. Each unit receives orders from which magazine it is to draw its food until its arrival at the point of assembly. At the same time regulations for the demand and issue of stores from magazines are laid down.

Lastly, in the plan of supply, another most essential question must be solved, where, when, and how, are the mobile magazines to be organised? We have already said that these magazines are always formed of hired carts; consequently they must be formed in that *rayon* wherein the army is concentrated, while as points of assembly for the carts, are appointed those centres where the magazines are situated, as they have to be filled with stores from those magazines.

To decide this question, we must know with accuracy the number of carts to be calculated upon in the *rayon* of the army's concentration, the number of draught horses, in what area we can collect the number of carts necessary to form the mobile magazine, how much time is required to collect these carts, for their organisation into trains, and for lading. When this is ascertained, we can calculate when the collection of carts should commence, and how this collection should be made, where and in what quantity they should be collected, how organised into trains, when they should be ready, in what order and at what distance they should follow the army.

The collection is always made through the local civil authorities, and should begin concurrently with the assembly of the troops, and sometimes even earlier, as for

instance in a poorly populated country, where the collection has to be made over a large area. To form the mobile magazine from hired carts is generally impossible, being too costly. Thus in 1853, when Paskewitch tried to form a mobile magazine of hired carts, the drivers demanded from two to three roubles a-day, and when in 1866 the Austrians formed a hired mobile magazine, they had to pay about eight roubles per diem for each cart. In consequence of this, the carts are ordinarily collected by order, while the payment is fixed by a Government tariff. Thus in our Danube army in 1853, the drivers in the mobile magazines were paid 60 kopecks, (say 1*s.* 9*d.*) for each cart; the Austrians in 1866 paid about three roubles.

Before the troops are concentrated, the mobile magazine should be formed. When military operations commence, it follows ordinarily one or two days' march in rear of the army.

Supply of the Troops during Military Operations.—We will now pass to a consideration of the second part of the task of supply: *during military operations.*

It has been already said that the essence of this task is to adapt the supply to suit the ever-changing circumstances of war.

It is a task of such a nature that it is impossible to lay down rules for its solution. Consequently it will be of no advantage to consider what measures should be taken for guaranteeing the supply of the army. A single unforeseen accident (and they are endless in war) may completely upset a whole series of carefully considered measures. Hence, we have no intention to take upon ourselves the task of explaining how to guarantee the supply of troops in war, but shall limit ourselves to a few general observations, and as an illustration, cite an example from military history.

From the time military operations commence, the supply of the army from magazines at the base becomes in most cases impossible. When the concentration is effected, the troops at once move forward in compact masses, and in proportion as they approach the enemy, occupy less and less space. Under these conditions, the supplies are drawn from the mobile reserves, but these very reserves must be at once replenished by one of the following alternative means:—

1. Either by requisitions in the theatre of war.
2. Or, if these means are insufficient, or if it is impossible to make use of them, from the mobile magazines, which in their turn must also replenish the expenditure from local sources or from the stationary magazines in rear of the army.

But in both cases the replenishment of the expended mobile reserves is an exceedingly difficult matter. In order that they may be replenished without being detached from the army, it is necessary that it should halt. Because if the empty carts are halted to replenish while the army is in movement, they can never be expected to overtake it; the train is not in a condition to move with greater rapidity than the army. All that can be hoped for it is that it may not be very far in rear.

Consequently in the case of an army supplying itself from its mobile magazines, all the labours of the intendance must be directed to guaranteeing their timely replenishment.

To this end it is necessary to make use of every opportunity to bring up stores while the troops are halted. A day's halt seldom occurs when near the enemy; consequently it is necessary to make use of that time when the troops are halted, or immediately before the engagement.

If possible it is better to bring up supplies collected by requisition or carried in the mobile magazine direct to the troops at their bivouacs; by this arrangement time is saved, and the mobile reserves are left intact for the critical day.

But the stores of the mobile magazine can scarcely be brought up direct to the troops. As this magazine ordinarily follows not nearer than one march behind the army, under the best circumstances it can only reach it at night, while up to that time the troops will not halt. Consequently they can scarcely replenish the expended stores of the regimental train from the supplies in their mobile magazine.

Simultaneously with the commencement of the forward movement of the army, the lines of communication with the base are organised, *i.e., étappe* points are formed at each halting place; to each of these points is assigned an *étappe rayon*, and in these *rayons* there commences a systematic collection of provisions. On the rapidity

of forming and filling the *étappe* magazines, and generally on the completeness of the organisation of the *étappe* administration, will depend to a great extent the punctual renewal of the expended mobile reserves of the army. The collection by requisition should, theoretically speaking, commence as soon as the advanced guards of the columns pass those points which are appointed as the halting places of the main body of each column; then, under favourable conditions, especially if we pay liberally, we may sometimes succeed in collecting before night a sufficient quantity of supplies to fill up wholly or in part those expended that day. Under this arrangement, magazines established at the halting places of the main bodies serve at first as expense magazines, and afterwards, when the troops leave, become *étappe* magazines. But if circumstances do not admit of these magazines being established with such rapidity, the *étappe* magazines before receiving their exclusive function must send after the army transports with supplies collected from the inhabitants, in order to fill up the reserves of the regimental train. But if time does not allow of this, these stores must be completed from the mobile magazines, and at the *étappe* points transports must be formed with a reserve of supplies sufficient to complete the mobile magazine.

With regard to the supply of the advanced guard, no care need be taken if the war is conducted in Europe; their numerical force is such that they can always find at the halting place or in the immediate vicinity sufficient food to replace that which has been consumed during the day. But it is more difficult to collect enough for the main bodies, as the resources of these localities are already drained by the advanced guards. It is of course essential that when the supplies are taken without payment, each advanced guard should have its intendant, with a staff and escort, otherwise it will not be able to collect what is wanted.

On the day of battle, the troops have generally to draw on their knapsacks, as the train left in rear cannot always come up in time to the halting place if victory is gained, while in the event of a retreat, it must withdraw still more to the rear, and consequently there will be still less likelihood of the troops being able to draw upon it. Moreover, on the day of battle, the expended stores of the regimental train can be best replaced by giving orders in the evening to the mobile magazine, or the transports filled by requisition, to get close to the spot where the train is appointed to await the issue of the contest. Thus the time the regimental train is waiting at these points should not be spent in idle expectation, but should be used for the advantage of the army.

After the engagement, the mode of supply will depend on its result.

If the enemy is defeated and the army pursues, it may advance on a broader front than before the collision; this accelerates the movement and facilitates supply, as the broader the front, the less the number of men and the depth of each column, and the more easy to utilise the local resources, and the more quickly can the regimental train and parts of the mobile magazine be brought up. Nevertheless, the provisions will have to be taken from the mobile reserves; the only difference is that the replenishment can be more easily and quickly effected than before the collision.

The activity of the *intendance* on the line of communication increases more and more in proportion as the army moves forward. Danger from the enemy becomes diminished; influence over the inhabitants increases; the requisition *rayons* in consequence become more and more enlarged, and stores may be collected in larger quantity. In the requisition *rayons* large and rich towns commence to enter; this enables one to pass from requisition in kind to contributions in money, so that with the money so collected supplies may be acquired from the inhabitants by purchase. This method, as we have before remarked, tends much to improve the supply conditions; as soon as there is prospect of good payment, provisions commence to flow into the hands of the intendants.

As the *rayon* of requisitions becomes enlarged, the possibility arrives of organising a rapid transport of supplies from the base and from home territory. Until important successes are gained, it is difficult to make use of railways for bringing up supplies, while in the enemy's country it is at first not generally practicable as these roads are usually rendered impassable. But in proportion as the army moves forward the lines are repaired, brought into connection with home railways, and opened to traffic. Consequently success, generally speaking, lightens

the task of supply. But in a rapid advance with frequent engagements, serious difficulties may arise, particularly until the traffic by rail is opened along the line of communications. A retreating hostile army leaves behind it an exhausted country, from which the assailant can obtain nothing in the short interval of time during which he remains in it, consequently he will have to make repeated use of his mobile reserves. When moving rapidly, it is difficult to replenish the constant expenditure, so that the assailant may be compelled to halt long enough for the mobile magazine to come up, and to remain halted until it is replenished from the rear. And the longer the line of operations, the more difficult to make the rate of bringing up supplies conform with the rapidity of the army's movement, and consequently the more serious the supply difficulties.

There is but one mode of obviating these difficulties under the above-mentioned circumstances; we must bring up the base to the army; that is to say, the time of transport must either be shortened, which can only be done provided the railways are at our disposal, or we must arrange an intermediate base. Then the magazines which form this base replace the primary ones.

The magazines opened along the intermediate base are replenished by whatever means attain the object most quickly. Consequently these magazines may be filled by purchase, by requisition, or by transport from the primary base, or by all these systems together. It is not a question what method should be used, but how best to guarantee the army; to attain this object every means is good.

In the event of retreat, the mobile magazine and the regimental train receive orders to proceed rapidly to such a distance that the retreat of the troops may not be delayed. In consequence of this it becomes very difficult to make use of these mobile magazines. Neither can the requisition method be calculated upon; time will not allow of its regular adoption, while to permit troops to make requisitions on their own authority is simply impossible, from a feeling of self-defence. This method in the offensive, demoralises the troops and prejudices discipline, while its adoption during a retreat may lead to the complete dissolution of the army.

There remains consequently but one mode of supply, viz., from those reserves which must always be in the *étappe* and expense magazines on the lines of communication. From this it is evident of what importance it is that the *étappe* points should be formed immediately after the army has passed through, and that there should always be in them a sufficiency of commissariat stores. If these stores, in the event of success, lie some time unused, it does not follow that they were collected in vain. No one can foresee how the fortune of war will turn, and we must always be ready to lighten the consequences of a possible reverse. From a supply point of view, measures of precaution against ill-success consist in guaranteeing the army with stores along its line of communications. If there is always in readiness at each *étappe* point a one day's reserve for the army, it may be considered safe in the event of a reverse.

Of course that part of the supplies which cannot be consumed or carried away must be destroyed, so as not to fall into the hands of the enemy. It is necessary to remember that the surest means of damaging the adversary's power of pursuit, is to throw supply-difficulties in his path; difficulties of this nature force him to halt. The destruction of the supplies devolves upon the main body, as the rear guard is fully taken up with warding off the pressure of the enemy. But after destroying the superfluous stores, the main body should have sufficient for the day's consumption of the rear guard, and should communicate beforehand to its commander where the supplies are to be found.

When circumstances permit, recourse may be had to a special mode of supply from the local resources, viz., by quartering the troops on the inhabitants. This is only possible however in densely populated districts and when out of striking distance from the enemy: for example, in the case of the main body, when it is a considerable distance from the enemy; in the siege of fortresses; and for detachments operating in secondary theatres of war.

The essence of this mode of supply consists in the troops being bound to receive food in kind from the inhabitants: a fixed quantity for a definite rate of remuneration. The nature of the meal and the scale of payment are determined by the Commander-in-chief, and communicated to the public through the local authorities. The

supply by quarters is divided into the full and the half rate, the householder in the latter case finding only soup, and the soldier bringing his own bread.

In Austria and Germany the nature of the meal is laid down, but with us the tariff is left to the Commander-in-chief, who takes into consideration the resources of the theatre of war. It is a very advantageous system, being cheap and simple, while it entails no trouble. The Germans made use of it on every opportunity. But it cannot be used in the vicinity of the enemy, or for large forces concentrated in a small space; and with the least want of vigilance, it may lead to irregularities and acts of violence, as the soldier is prone to overstep the limits of the requirements to which he is entitled by the tariff.

In conclusion of our article on "The supply of an army in time of war," we will give a sketch of the supply of the army of Prince Frederick Charles during the Franco-German war. It will serve to elucidate the question of supplying large armies in war better than any theoretical dissertations.

This army, consisting of seven corps, was concentrated on the line Bingen-Mainz-Worms. First of all, the troops were brought up by rail, and then, when the transport of the troops was finished, the train of all seven corps was moved.

The commissariat train could not come up before the army took the offensive. With each corps there should be 150 four-horse waggons of Government commissariat train, 400 carts of the commissariat park of hired carts, and 600 *étappe* commissariat carts.

During the concentration, the troops were supplied from stores purchased in Holland and Belgium; these stores were brought up the Rhine in hired boats.

But when the offensive was taken, both these Powers, being neutral, thought it their duty to forbid the transport of stores to the German army. Not having either magazines on the Rhine nor commissariat train, the army of Prince Frederick Charles was forced to have recourse partly to purchase for ready money, and partly to requisitions, although the offensive still lay through friendly country, the Bavarian Palatinate. During the offensive movement, a commissariat park was formed for each corps, partly by arrangement of the local authorities, partly by hire. To replenish the park, the corps commanders received full power to purchase stores of the local inhabitants at any price. This measure proved very effective. As soon as it became known that good prices were paid for commodities, the local inhabitants hastened to the army with their wares, so that the mobile reserve of the army was organised on the march before crossing the French frontier.

At the same time was coming by rail a large quantity of commissariat stores, of which large depôts were organised in the towns of Kaiserslautern, Hombourg, and Neunkirchen; while subsequently vast magazines were formed on the Rhine, which thus became the base of the army.

After the action at Forbach, large quantities of the enemy's supplies, stored in Forbach and Saargemünd, fell into the hands of the Germans; these provisions served for the current wants and for completing the mobile reserve of the army.

Up to Metz the army was supplied by requisitions; but when Metz was invested, the concentration in a small area, and in a devastated country, forced the Germans to look for their supplies to their own magazines. First of all, however, they took from the inhabitants all they could, and only ceased these requisitions when they were convinced that the local population was literally threatened with starvation.

The lines of communication were from Neunkirchen by two lines of rail, but from thence to the station of Remilly (thirty-seven miles this side of Metz) only one. Supplies were brought from Bingen, Neunkirchen, and Saarlouis where large depôts were formed. The terminal railroad stations were Courcelles, Remilly, and Herny, whence the stores were brought up to the army in carts.

This single line of communication proved inadequate. Hence communication was opened with the base by another line of rail from Weissenburg through Nancy to the stations of Ars-sur-Moselle and Novéant, on this side of Metz.

The formation of this new line of communications guaranteed the supply in such manner that, when Metz was taken (29th October, 1870), the Prussians could furnish food for all the captive French army and the inhabitants, and subsequently

took the field against the Army of the Loire fully provided not only as regards the Government commissariat train, but in the commissariat park, *i.e.*, with ten days' supply. We may remark in passing, that this commissariat train reached the army just before the surrender of Metz.

On the march from Metz to Fontainebleau, the Prussians expended their mobile ten days' reserve, and three times replaced it by means of requisitions. After reaching Fontainebleau, before the commencement of military operations against the Army of the Loire, this reserve was again replenished from the same source.

During the military operations on the Loire, the requisition system proved inapplicable: the country was completely exhausted. Hence the army was supplied at first by rail transport from Germany; but when Orleans was captured, they had to abandon this arrangement, owing to the great distance from the terminal station, as it was impossible to organise a satisfactory wheel transport for the purpose.

Then they had recourse to supply by purchase for ready money, collected of course by contributions.

In Orleans and some other towns in the *rayon* of the disposition of the army markets were established. This measure again proved very successful: the supply of the army, which had scarcely any communication with its base, was perfectly ensured. In Orleans a central magazine was even organised; into this magazine were brought from Germany tinned food and the well known peas-sausage. This sausage was the staple food of the Germans during the operations against Chanzy's Army, as the neighbourhood of Le Mans was completely exhausted of supplies, and it was impossible to obtain anything by requisition or even by purchase.

But fortune favoured the Germans. The peas-sausage was nearly expended when they captured Le Mans, finding there large stores which sufficed for several days, and in the second place the rolling stock of the railway, with the help of which they could at once re-establish connection with Versailles, and consequently re-open their line of communication with their base. This line, however, was interrupted at several places during the war, so that they were obliged to have recourse to transport trains as a subsidiary means.

Only on the fall of Paris was there any possibility of organising uninterrupted communication with Germany by rail.

At the conclusion of peace, the German troops received supplies from the inhabitants on whom they were quartered.

With this slight sketch we shall conclude our remarks on the supply of the army, observing that it is the most important and difficult of all administrative questions—a question which at the present time cannot be said to have received a thoroughly decisive solution.

STAFF TOURS OF FOREIGN ARMIES.

By H. E. Rawson, Lieut. R.E.

Common sense dictated the apophthegm:—

"If peace thou will'st, prepare for war;"

but the history of the present century does not go very far to support it. The nation at which jealous opponents point the finger of scorn as least ready to defend its rights by arms, has had its tranquillity broken but once—there have been ripples on the water, but no more—since 1815. The nation whose very social independence is given up in order to be prepared for war, broke the peace of Europe thrice in six years. The theoretical truth of the old saying cannot however be doubted. No one fails to understand its meaning. The true meaning, as we apprehend it, is that during peace those measures should be taken which are essential for securing success in time of war.

The application of this truth by continental nations to the training of their Staff Officers, is the subject of this article.

Before describing, however, the Staff Tours employed as a means of Staff preparation, it will be as well briefly to state the duties of a Staff in war and in time of peace.

In war, the Staff must procure and compile in a concise form everything that is to be ascertained about the intended theatre of operations, with as detailed maps of the localities as exist, and without omitting the smallest statistic which can be of value; they should obtain information of everything going on in the enemy's ranks, sift news and transmit it to head-quarters; they should issue the necessary orders for encampments and bivouacs, for marches and for engagements; they should be the channel for all orders issued on the field, whether verbally or otherwise, and should be able to amplify and elucidate them so as to be readily understood; it should be their constant endeavour to perfect the efficiency of the troops for combat by attention to their wants, and should therefore have an accurate knowledge of their condition; they should be employed on special missions of urgency, whether to explore a road, make a reconnaissance or occupy a position of trust at the head-quarters of a co-operating ally; they should keep journals of the day's operations, frame reports of encounters, and collect accounts which may afterwards serve as a record of the campaign; finally, they should relieve the General in Command of every question of detail, transferring his ideas into the orders they issue.

The aim of officers of the Staff in peace, should be to prepare themselves for the duties they will have to perform in war. Those who are in direct contact with troops should be acquainted with the necessary measures for mobilisation, and for maintaining their efficiency in the field, with the details of manœuvres, with the proper distribution of troops over ground, with the movements of men by railways, and with the working of telegraphs. Staff Officers doing duty at head-quarters have the same measures to take for the whole army that the staff of districts take for the different branches. They are in a position to know everything that is going on, and should therefore be acquainted with the organisation of all the continental armies and the changes taking place in them. They should be prepared to plan in detail military operations that may possibly be undertaken. Maps should be compiled under their direction, as well as all information interesting to the army; the instruction of junior officers at places of learning should be especially under their direction. They should collect all statistics about other countries, and about colonies and dependencies of their own country, which, on the outbreak of war, might prove of value to the force sent to operate there. In common with Staff Officers attached to troops, the organisation of their own army and military history should be studied most completely. Their knowledge of the organisation of the army should extend itself far beyond an acquaintance with the component parts of a *corps d'armée*. They should know the relation each branch bears to the rest, and the special regulations governing the employment of each. From military history they should draw their own distinct conclusions as to the best way of increasing the efficiency of the troops before a combat, and during the various phases of success and failure. They should work out in all their details, plans for mobilisation and concentration, for transport of troops by road, rail, or water, and for the service of posts and telegraphs in the field. Finally, they should acquaint themselves with the measures prepared for the defence of the country.

Opportunities for mastering these duties are afforded to the Staff Officers of some continental armies by means of the Staff Tours now to be described. These Tours, which are held annually, take the form of a gigantic skeleton drill applied to a *corps d'armée*. In the extensive manœuvres thus carried out, a Staff Officer is enabled to apply practically the knowledge he acquired theoretically whilst training for his work. With the Staff Officers, Regimental Officers are associated.

Staff Tours have been carried on in Prussia ever since Colonel von Massenbach was Chief of the Quartermaster-General's Staff Corps. He thought it possible to have an official register made of all the military positions throughout the country, and to draw up the plans which should regulate the operations of an army moving in them in war. For this purpose he instituted a series of Military Tours for Staff Officers in 1803, and obtained a vote of 10,800 thalers or over £1,600, for their expenses. His ideas did not meet with favour so far as they determined the plans

for the future operations of an army; but he employed Staff Tours to ascertain, down to the smallest detail, the offensive and defensive positions of the country. Under his successor, the Tours were annual, and are spoken of as "reduced to three "months in summer." They now included visits to foreign countries. At the present day, they form a principal feature of the instruction given to Staff Officers. The Chief of the General Staff determines in what districts they are to be held and what information is to be gathered, and in this way they are a valuable means of supplementing the work of the departments he controls. Those undertaken by the Great Staff are superintended by himself in person, or by one of the heads of departments. Regimental officers are authorised to take part in them, but only a very limited number. The applications of two officers commanding regiments and of two other field officers are all that are entertained. There are also annual Tours of the Staffs of *corps d'armée*, in which officers of all arms are associated with the Staff. The Chief of the Staff fixes what corps are to take part in them, and the generals in command select the officers. The number of regimental officers is limited to two Field Officers of Infantry, Cavalry or Artillery, three Captains of Infantry or Artillery, one Captain and one Lieutenant of Cavalry, and three Lieutenants of Infantry or Artillery. Each War School may also send one officer. A detachment of Cavalry accompanies the Tours and Infantry, also if the scheme or General Idea of operations requires them. The former are always employed, as everything is done on horseback. The Tours usually take place in the autumn, after the manœuvres.

Though Sweden adopted the idea of Staff Tours in 1864, and Norway in 1867, none of the great European powers followed the example set by Prussia till 1871. Russia was then attentively considering the question of Army Reform, and among its first measures instituted annual Tours for the Great Staff and the Staffs quartered with troops in the various districts. It had made one attempt previously in 1835, but did not renew it till this year. Staff Tours were made in four districts in 1871. The work that was done during them has been published officially, and as it is typical of its kind, we shall deal with it presently in full. Since that time Austro-Hungary, and some of the Federal German States have done the same thing, while Italy and Switzerland have made them part of the course which officers have to go through at their respective Staff Schools.

The General Idea may be either one of a single action where only one force is supposed to be in the field and the enemy is entirely imaginary, or one of a double action. If the Idea be one of a double action, the officers are divided into two parties and carry out the manœuvres of two contending armies. Mounted detachments are then told off to each, who serve to indicate the component parts of the operating forces. This they do by carrying different kinds of flags expressing different troops. From a consideration of several of the Tours which have taken place, it is beginning to be allowed that the double action affords greater advantages than the single action. It is easily carried out and with satisfactory results. The increased number of officers engaged adds greatly to the value. Where only one force is represented it is possible to pass more gradually from simple to complicated manœuvres, and to repeat what is unsatisfactory. But the criticism on them will be made by the same person, and the danger of their being all drawn on the same lines is great. Besides, in the single action the attention of the officer directing it is concentrated on it alone, and he becomes a sort of instructor watching the progress of details, and not that of the whole. The officers consequently lose that individual independence which they enjoy in a double action, and which is most profitable. Whatever the problem to solve, the decision of the Chief directing it should be conclusive, but his judgment and estimation of the work will be more just if open to the opinion and criticism of several as in a double action. In this latter case also, the decision of the Umpire upon any manœuvre depends on the dispositions and operations of the Chief directing the party who executes it, and his control over affairs; and even his final criticism, will be guided by the views of the responsible officers allied with him. All this prevents a narrow and one-sided opinion. There is no similar check in a single action. Where there are two rival parties the errors of judgment of one are often demonstrated in the manœuvres of the other, and one side will be ready enough to correct the other. The discussion thus arising, and the

interest developed, add greatly to the instruction derived, as well as to the advantages of the work. These are pretty much the views of General Leontief after the first Russian Tour in 1871, which he, as Governor of the Academy of the General Staff, planned and executed. The later Tours have confirmed them.

Staff Tours are generally commenced in one of three ways:—

In the first, the outline or General Idea is issued and the officers are assembled the same day *on the ground* chosen. Army Corps orders are then drawn up by the Chief, specifying the hour of advancing and the general positions to be taken up as camping grounds by the divisions. The movements of the cavalry, which will be the principal arm used at first, should be given with great preciseness. To execute the orders effectively, an examination and report of the ground will have to be made at once. This will include roads, lateral communications, ground for camps, and points to be occupied by cavalry outposts. Divisional and brigade orders, framed according to the Army Corps orders, then follow.

In the second, after the General Idea is made known, a certain length of time is given officers to prepare reports on the ground from maps and information in their possession, and to draw up all statistics that can be collected. If the problem is one of a double action, the movements may be commenced by a judicious use of Kriegs-spiel. After anamount of preparatory work, resembling what would actually be the case upon the outbreak of war, the officers repair to the positions to be taken up. Throughout the whole of the preparations, strict secrecy as to the movements of the two parties must be maintained.

In the third case, Tours are undertaken for a special object, such as to plan the defence of the country, to investigate the frontier, to correct maps, or to obtain information required. The Austrian General Staff have in this way compiled two volumes containing every statistic required in war. One volume has a general description of all theatres of war, the other of all routes along which armies will probably march. Corresponding with these volumes are two sets of maps—operation maps and route maps. In the latter, the roads all over Europe are divided into day's marches, each of which has a number referring to a certain page of the "Route "Description." Turning to the same number there, a military description of the road and neighbouring positions will be found.[1] Equally valuable work is done during the Tours of the Great General Staff in Prussia, and at the same time the regular duties of the Staff of an army in the field are not neglected. The provinces of Alsace and Lorraine have furnished much new ground for study. In 1872 the Field Officers and senior Captains of the Great Staff under Count Moltke made one of their annual Tours in the Belfort-Colmar district, which they examined during part of August and September. Again, in April, 1875, an exceptional Tour was made by the Staff of the 14th *corps d'armée* (the Baden Corps) in the same district. It lasted 14 days. The detachment was composed of 18 officers of the Staff, 4 rank and file, 21 orderlies and servants, and 38 horses. They made detailed sketches of the ground and reconnoitred the military positions as well as the roads, with a view to the grand manœuvres being held on the French frontier in the autumn. In 1873 and 1874 the Great Staff were engaged in considering the defences of the coast along the Baltic and North Seas. The first Tour was held between Harburg and Wilhelmshafen, and the second, in which 10 Field Officers and 20 Captains took part, extended eastwards to the Bay of Lubeck.

In Italy, Staff Tours are known as *logistic campaigns.* They have been carried out on an extensive scale for some years by the third-year students at the School of War, but until 1875 they were never applied to the Staffs of brigades and regiments. In June of that year they were introduced by an order. "Norme per la manovra coi "Quadri," or "Regulations for Manœuvres in the Army," have become general. The most important of those undertaken by the students of the School of War was in 1874. It lasted fifty-five days, and extended from Mont Cenis to Pisa, embracing, amongst others, the neighbourhoods of Stradella, Modena, Bologna, San Marcello, Lucca and Pisa, and the coast line of the Gulf of Genoa from Sævona to the Arno. They studied the lines of invasion through these places, the positions near them,

[1] Cf. a lecture on the Intelligence Department, by Lt.-Col. C. B. Brackenbury, R.A., in No. 81 of this *Journal*, 1875.

and the facilities for embarkation along the coast. The port of Spezzia was also examined for its stragetic importance as the base of naval operations. The problem consisted in marching an army of four Corps across the Apennines, from the sources of the Po to the plain of Tuscany, in order to oppose an enemy's force supposed to land at Viareggio and Leghorn.

The Swiss Central Federal School at Thun for Staff Officers has executed Staff Tours of the same kind since 1871. Denmark began them in the same year; and Belgium followed in 1874.

In the spring of 1871, the Emperor of Russia ordered Staff Tours to be organised on the model of the Generalstabesreisen of Prussia. A scheme was then concerted by which the whole of the General Staff would be instructed in three years. Tours were to be held annually in each of the military districts, in which equal numbers of Officers of the Staff and of regiments were to take part. It provided that weak detachments of cavalry or of Cossacks should accompany them to furnish horses for unmounted officers, and to be employed on the field to indicate the disposition of the troops and act as gallopers. It fixed a sum of money to cover the daily allowance to officers, the cost of travelling, of canteens in various places, and of maps during the Tours. The General Idea of the manœuvres was left to the General Staff and to the Committee of Military Instruction.

On these broad principles the first Tour was arranged to be held in the province of Livonia, bordering on the Gulf of Riga, in the months of May and June. The direction of the operations was confided to Lieutenant-General Leontief. He decided on a double action, of which the following is a short outline. An army from the West has blockaded Dunabourg, and is marching on Pskov with St. Petersburg as the objective. A *corps d'armée* has been detached from it which has occupied the town of Riga and advanced to occupy the whole province of Livonia, intending to drive out the enemy and effect a junction with the principal force before St. Petersburg. It is known that the bulk of the corps has arrived at Volmar, and is pushing forward along the Valk and Fellin routes. It cannot count upon reinforcements from the main army until Ostrov has fallen. The eastern, or defending, army, is concentrating round Ostrov. One of its corps is withdrawing on Derpt, with its advance guard fourteen miles in front of Valk. Troops are hurrying up to reinforce it, and reserves can arrive from St. Petersburg in time for the subsequent operations. The town of Derpt and the whole of the province must be defended to the last. The Eastern Fleet is mistress of the Baltic Sea.

The detachment taking part in the Tour consisted of forty-one officers, of whom nineteen belonged to regiments in the district of St. Petersburg. They were divided into three groups:—

Commander.	Party.	Officers of the Staff.	Officers of Regiments.	Total.
Gen. Leontief	*Umpire* ..	6	4	10
Gen. Obrontchef.. ..	*Eastern* ..	8	7	15
Gen. Herchelmann ..	*Western* ..	8	8	16

The strength of the Eastern Corps was 52 battalions of infantry, 136 guns, and 8 regiments of cavalry. It had besides 2 military telegraph troops, 4 field divisional hospitals, and 15 ambulances.

The Western Corps had 54½ battalions of infantry, 152 guns, and 8 regiments of cavalry, 1 military telegraph troop, 4 field divisional hospitals, and 16 ambulances.

Each party was acquainted with all the data of the problem, but was not informed of the other's strength. The groups worked separately from the first. They assembled in St. Petersburg during the last week in April, and commenced the preliminary measures which had to be taken before repairing to the ground. Each side determined on the general plan of his operations. The Eastern party elaborated the details for defending himself in case of a retreat to St. Petersburg. The Western party formed a plan of campaign to invade the province of Livonia and to move sub-

sequently on the capital. Each side had moreover to take measures for feeding his troops, and for supplying the artillery and hospital services. These preparations were full of interesting questions of general strategy and military administration. They required a careful study of the localities by the aid of the existing maps, and of the resources at the disposal of the army from military statistics at hand. These were compiled in a series of written memoranda. They ascertained the amount of grain, the supplies of stores, the means of transport, the number of markets, and of mills to be found in the district. They fixed the quantities of provisions to be stored in the magazines and the sites for each, and described those they selected for the hospitals. They organised the route-service in rear of each army. The artillery service consisted of detailed tables of the nature and calibre of the guns, the amount of ammunition required, and its distribution amongst parks of field and horse artillery. Provision was made for supplying the troops with ammunition, and for replenishing the parks; at the same time all the details of the parks and their field workshops were shown. In the same way the medical branch was organised to give assistance to the wounded and sick in the neighbourhood of the operations, and the measures pointed out for distributing the wounded amongst the temporary and field hospitals at points more distant in rear. Fifteen temporary hospitals on the usual scale were organised, and the sites selected. The details for all the other branches of the service were gone into with the same minuteness. In addition to these memoranda they framed regulations for provisioning men and horses, and for the movements of rolling stock by road and railway. The features of the country were fully described. The maps showed the nature of the roads, and of the bridges, the position of fords, smithies, telegraph stations, and all such information by conventional signs. Nothing was neglected in these preliminary steps which would assist the contending corps in their future movements, and would give them accurate data on which to go. When these were completed, the umpire decided that the opening movements should be made by the method used in Kriegs-spiel in order to concentrate both forces before the officers repaired to the ground. This concluded the preparatory work, and, on May 30th, the detachments left St. Petersburg for the positions held by the forces they belonged to. A month had been spent over it, but the officers had not been excused other work altogether, and some could only give a few hours to it at intervals. Only two evenings were devoted to Kriegs-spiel. It was considered at the time that it would have been an advantage if more opportunity of combined operations on the map had been afforded by the problem. This would have been the case if the data of Tours such as these, assigned such positions to the troops as would make them several marches distant from one another. Each party would then commence with the mobilization and the concentration of his force upon the theatre of war; as it was, in this Tour the latter was but little touched upon.

Before leaving St. Petersburg certain instructions as to the method and order of carrying out the operations in the field were issued to the officers. Each officer of the Staff was to consider himself in the position of a Chief of the Staff or of a senior aide-de-camp, and not as in command of troops. He was to write out every evening in the form of a journal the work prescribed him and the work actually done, the method of carrying it out, and his observations upon the omissions and inaccuracies of the map. His dispositions for the following day were also to be transmitted there to the Chief of his party. Each party was to keep a journal of the operations, stating the motives for all, and was to present to the Umpire daily the dispositions, the place of assembling, and the distribution of the work amongst the officers for the following day. The sketches aud reports were to be collected daily. The officers attached to the Umpire were to keep a general journal of operations and tabulate all reports sent in. Everything was to be executed in the time and place agreeing with that which would be the case if the troops were really present. The Umpire would inform each party of the operations of his adversary as the occasions arose. The Chief of each party would be responsible for the correctness and *bonâ fide* character of the work. No delay in completing it was to be allowed, and the exact time spent on it was to be stated. All reconnaissances and plans were to be made to a scale of four inches to a mile, road sketches to one of two inches to a mile. These regulations were throughout strictly adhered to.

With the knowledge of the positions occupied by their troops which they had

obtained from Kriegs-spiel, the officers repaired to the ground itself. So far they had worked out what may be called problems of military administration, such as provisioning the troops and organising the transport. Now they had to collect information which could only be obtained on the spot. A series of reconnaissances, written reports and sketches of roads, rivers, and positions, were commenced to serve as data for further operations. This lasted till June 7th; on the 9th, the strategical and tactical manœuvring of the troops on both sides began. Besides preparing and executing the movements planned for the first day, the officers of the Eastern or defending corps selected and reconnoitred three positions, with a view to occupy and fortify them. They traced bivouacs and made some road reconnaissances. The Western or attacking corps drew out in detail the tactical measures for the passage of the river Cedde. Plans of the necessary field works for it were made. Sketches, reconnaissances and reports completed the day's work.

On the 10th, the Eastern Corps chose and occupied a position to be held by the rear guard. They surveyed the river Embach, with the intention of crossing at Teilitz, and a Staff Officer of Engineers fortified the place. The Western Corps reconnoitred the roads by which they proposed to advance, and selected three positions in which to receive the enemy if he was reinforced and attacked them. Both parties chose bivouacs and placed outposts. The orders for all movements were made in writing every day. The operations of these two days had necessitated a great deal of work on horseback, and the 11th was employed in duties not requiring physical exertion.

June 12th. Besides the work immediately connected with the military operations of this day, such as reconnoitring roads, the officers of the Eastern Corps chose positions for the rear guard and for the whole of the corps in case it was thought advisable to await the enemy. They also made the dispositions for the bivouacs and outposts. Those of the Western Corps reconnoitred the localities into which they were advancing, and selected a position should they be attacked. The following day was a Sunday.

June 14th. An engagement took place between the advance and rear guards during the passage of the river Embach by the Eastern Corps. This party also made a detailed reconnaissance of a position at Pekokeil and the ground on each flank. The Western Corps selected a position for the advance guard, and placed a line of outposts. Both sides planned bivouacs for their troops.

June 15th. The Eastern Corps being ready to receive an attack at Pekokeil, the Umpire inspected the position in person. The positions of the troops were pointed out by the officers, and those of the batteries were indicated in detail by means of the Cossacks who accompanied the party. The Umpire then declared the main features and the direction of the attack, and ordered measures to be taken to repulse it. Meanwhile the Western Corps had made a reconnaissance of the position. The dispositions of the two parties having been laid before the Umpire, he declared the attack to have been repulsed and an assault made by the defenders. The Western Corps chose a position at once. The work of sketching and reconnoitring it was done very rapidly, and after an hour and a quarter, a verbal explanation of all details of the positions of the troops was given, batteries were again indicated by Cossacks with flags.

June 16th.—Manœuvres without an engagement formed the work of the day. Particular attention was paid to outposts and bivouacs. Each officer was given about three miles of country to sketch and report on for a line of outposts. The following day no work in the field was done.

June 18th.—The Eastern Corps studied in detail the position of Derpt, front, flanks, and rear; made a project for putting it into a state of defence, for the distribution of the troops, and for preparing to assume the offensive at a given point. They assured their retreat along the river Embach. The Western Corps chose a position for the advance guard, and disposed the bivouacs and outposts.

June 19th.—The Umpire inspected the position at Derpt, and ordered steps to be taken to enable reinforcements to cross the Embach and come into position. The Western Corps reconnoitred the enemy's defences, and selected a line of retreat and a position in case their attack was repulsed. This concluded the operations in the field. The officers had been nineteen days at work, and, in spite of much fatigue,

were all in health and spirits. At work they wore their tunics without swords, and when the weather was bad, waterproof clothing. One officer in each group catered for the rest. Many improvements upon their equipment were found necessary. The leathern sketching cases were abandoned for ones of strong waterproof linen, while some preferred sketching blocks mounted in a *sabretache*. The paper issued to them was too thin and it was found necessary to get stronger. Horses were provided for the officers from the detachment of Cossacks, and were taken care of by the men; but this practice gave entire dissatisfaction. During the last days of the Tour, work always lasted from 8 A.M. till 3 or 4 P.M., and more than once it happened that those who had to place the outposts did not complete it till 8 or 9 P.M., having been in the saddle since 8 A.M. Everything was done on horseback that allowed of it. On these occasions no officer acknowledged to fatigue, and it was an undoubted fact that even in nineteen days they became accustomed to the hardships and privations of bivouacing. All, without exception, were firmly convinced of the necessity of renewing the operations in the field another year, and that they were an admirable means of developing the faculties most essential to a Staff Officer. They acquired the power of finding their way about the country by the aid of maps, and of appreciating readily the value of a position for military purposes. It often occurred that after a rapid reconnaissance, they were called on to decide upon a line of defence, upon a direction for an attack, or upon the necessary dispositions for bivouacs or outposts, and the execution of it at once followed the decision. The time given for a manœuvre required the measures to be simple and prompt, without an attempt at ideal perfection, but only attending to what was really efficient and essential. As often as possible, sketches were made on horseback. Descriptive reports requiring accuracy in details were done after the officers returned from work. The district chosen for this Tour was not one which was likely to become a theatre of war in any future time, and being so close to St. Petersburg, a good deal of information about it already existed. Many proofs, however, occurred of the incompleteness of military statistics connected with it and the necessity of correcting those that existed up to date. One permanent work of military administration was carried out during the tour by a Colonel of the Staff. It consisted of a detailed project for a new line of communication traversing the district. In the report which was made by General Leontief, on returning to St. Petersburg, he expresses the hope that in future, Officers of the Intendance, civil functionaries, and police may be associated with the Officers of the Staff. Their work would then have a permanent value. It would be possible to make plans for the cantonment and provisioning of troops, for the organisation of transport, and for the choice of sites for hospitals, magazines and route stations with a practical end in view. The Umpire would verify them on the spot. During the Tour, many of the officers, especially those who had not served with troops for some time, showed that they had great difficulty in making up their minds clearly on the dispositions and movements of the detachment they were with. General Leontief further declared that every Officer of the Staff ought to take part annually in a Tour such as this; while officers of other branches, not excepting general officers, should take part in them every second year. The regimental officers associated in the expedition this year joined in placing outposts and choosing bivouacs, and sometimes were employed in this way independently. They reconnoitred the approaches to a position, conducted a small body from one point to another, or to the attack, placed a battery, traced an entrenchment, and established a ford. But no tasks of a complicated nature were confided to them. Like the Officers of the Staff, they were employed in the preliminary reconnaissances from May 31st to June 9th. But it is evident from the Umpire's remarks on their work, that it did not give very great satisfaction. The suggestion is made that commanding officers should, in future, only recommend the most distinguished of their officers. The operations extended over about 86 miles of country from front to rear. The whole detachment returned to St. Petersburg on the 20th of June. The account of this Tour was submitted to the military authorities for their criticism and opinion. Many improvements were suggested and were applied in the Tours which ensued in the autumn of the same year in the districts of Moscow, Warsaw, and Kief.

The Tour in the Moscow district was of a similar kind to that which we have just described. An account of it has already appeared in No. 86 of this Journal, in an

interesting lecture delivered at the Institution by Captain F. Burnaby, Royal Horse Guards; we do not purpose, therefore, to describe it here.

The Staff Tour in the district of Warsaw, which lasted from September 17th to October 3rd was directed by General Minkwitz, Chief of the Staff of the District. The detachment consisted of:—

	Generals.	Field Officers.	Captains and Lieutenants.
General Staff	1	9	4
Regimental Officers passed through Staff Academy	1	2	1
Regimental Officers	—	1	8
Total	2	12	13

The general idea was one of a double action. The principal aim of the Tour being to study Military Topography, the opportunity was taken to verify the map of Poland and carry out four problems of military tactics. The officers proceeded at once to the ground and commenced a series of reconnaissances. It was divided into fifteen sections, each of twenty to forty miles square. This work lasted three days. The first tactical problem was a manœuvre between the two forces, which was executed in the same way as in the former Tours, except that when the collision occurred it was fought out as an exercise of Kriegs-speil on a map of one inch to one thousand yards. This was the case with all the engagements which took place during the Tour. When the work had been verified, the second problem was commenced. It consisted of a blockade of Ivangorod on the Vistula, by a division of infantry and a brigade of cavalry, and the measures which an investing corps would have to take. The defence of the town was not considered. Some of the calculations were left till the officers returned from the field. But the establishment of the general line of posts round the fort, the distribution of troops and regular operations of a siege, the maintenance of the troops and the telegraph arrangements to unite the main reserve with the detached reserves of the investing force were all worked out. The plans were verified by the Umpire. The last few days of the Tour were devoted to two exercises in the dispositions to be taken for troops on the march.

The Tour in the military district of Kiev consisted of sixteen days' marches of a *corps d'armée* along the Austrian frontier between Konstantinov, Kremenetz and Rovno. The detachment was as follows:—

	Generals.	Field Officers.	Captains and Lieutenants.
General Staff	2	4	7
Regimental Officers	—	—	10
Total	2	4	17

The Chief of the Staff of the district directed the manœuvres, and elected the form of a single action. The *corps d'armée* numbered three divisions of infantry and one of cavalry, with artillery in proportion, and two regiments of Cossacks. No time was given the officers for preparatory work before taking the field, but the following memoranda were furnished to each of them:—

A. Short instructions upon reconnaissances, and the rules to be observed in

marches, in choosing positions, bivouacs and outposts; upon the depth of columns of different arms on the march, and upon dispositions for an engagement.

B. The effective strength of the *corps d'armée*.

C. The dispositions to be made in rear of the corps.

The general idea of the Tour was such as to practice the officers in maintaining "touch" between detachments marching along parallel routes, and the method of doing so is peculiarly interesting as a practical means of obtaining exercise in this important point. During the movement of the *corps d'armée* between Konstantinov and Rovno, it made a flank and offensive march on Liakhovtzov, and continued its operations on the flank as far as Jampol, a flank attack and a retreat to Kremenetz, a further retreat to Doubno, an offensive movement to a position at Verba, from whence it withdrew to Rovno. These operations extended over 188 miles, and lasted from September 27th to October 18th. Sixteen days were devoted to work in the field and six to rest and correspondence. Each Officer of the General Staff in turn acted as Chief of the Staff of a detached force. During a march, one always went in front to indicate from the map the route to be followed. The map of the district is one of an inch to three thousand yards. Its errors were corrected after each march, and the description of the roads traversed was accompanied by sketches of all the positions met with, as well as of the military features of the ground. On October 6th, five Staff and five Regimental Officers reconnoitred and sketched the course of the River Goryna for eighteen miles, on horseback. No opportunity was lost of solving such problems as arise in the march of separate detachments, *e.g.*, getting troops into movement after a halt, deploying into a position, making a forced march and changing the direction of the movement. Positions were chosen and occupied. The strong and weak points of an enemy's line of defence were pointed out. In many of the operations of this kind this Tour resembled all the others, but one essential difference was in the instruction to the officers in calculating exactly the movements of columns on the march, and in maintaining communication with detachments moving separately. It was carried out in this way. If in the manœuvre detailed by a previous general order, the front was small, the officers of the General Staff were distributed over all the roads included in it. They were to march and halt at the hours and places named in the orders, and to keep touch with the columns near them. A very practical method of trying whether they did so or not was found. Either during the march or before it commenced, the Umpire sent sealed instructions to the Commanders of separate columns, which they were to open at a certain time and place named. On opening one of these, the officer had to make the dispositions required by it. Sometimes it would order a slight alteration in his movements, which he would have to communicate to another detachment in front of him or on his flank. Sometimes he would have to deploy his troops and send word to the others to hasten to his assistance. In any case, knowing that at any moment he might be required to inform any part of the *corps d'armée* of a change in his dispositions, he had to keep an accurate calculation of all its movements. The officer belonging to his party whom he sent, would have to make his way along roads, or across country by the map. Three or four days' practice was found to enable the officers to determine correctly the positions of columns on the march, and to maintain constant communication between bodies of troops moving separately. Regimental officers were employed in carrying the sealed instructions and the reply from the officer concerned. The only objection found to this method in practice was that it took up a good deal of time, and prevented the officers from assembling for some hours after the movements were over. It had to be modified in the case of long marches. The officers all followed the same route in a body, but were *supposed* to be moving with their separate columns along parallel roads which had been previously detailed in orders. An instance of what occurred on October 3rd will make the method of carrying out the practice there clear. During a march of 18 miles all the officers were following the same route. By means of a written communication from the Umpire one of the officers acting in the capacity of the commander of a column on the right flank, was informed that at 10 A.M., the enemy was marching on Kortchevka. In reply he stated the measures he immediately adopted for the movements of his own detachment, and the positions of his own and all the other columns at

10 o'clock. He also calculated the hour and place they would receive information of the enemy from him. This intelligence was to be communicated to those concerned at the time it was held that it would reach them. Meanwhile the skirmishers of the advanced guard of the main army had been attracted in quite a different direction to Trousilovska by the sound of cannon. The Commander of the advanced guard had thereupon ordered it to halt and deploy, and the columns were hastened in the direction of the fight. Upon the necessary time elapsing they were informed that the enemy only had a single regiment of cavalry and half a battery of horse artillery there, whereas the greater force was at Kortchevka. The mistake of not first ascertaining the enemy's strength was thereupon pointed out to them.

The reports on the four Tours held this year were completed by December, and formed the basis on which a committee, headed by the Commandant of the Staff Academy, elaborated a scheme for the future conduct of Staff Tours. It was agreed on all hands that all officers of the General Staff should take part in them at least every second year, and that regimental officers of all ranks, and those of the Intendance and Medical Departments should be associated in them. With one exception, they were unanimous in preferring a double to a single action, the objection of the dissenting voice to the large number of officers required, to the loss of time and fewness of the questions which arise, being over-ruled. It was held that the preparations before entering the field should only last a week, and the work there three weeks for a double, and two for a single action. The work should be carefully verified on the spot. A general form of journal was compiled. The employment of markers to indicate the positions of troops was considered satisfactory, but the method of carrying out the details of a fight by their means, too tedious. In such a case, where it would be advantageous to work out an encounter, it would be better to do it on the map, as in Kriegs-spiel.

We will conclude this account of the Russian Staff Tours by one that has a special interest at the present time. It was undertaken in the autumn of 1874, and comprised a complete study of the mobilisation of the Russian Forces in the military district of the Caucasus. The completeness with which it was carried out, even if no other indications existed, makes it more than probable that operations in that neighbourhood were in course of preparation even then. The detachment consisted of:—

	Generals.	Field Officers.	Captains and Lieutenants.
General Staff	3	6	4
Regimental Officers	1	5	10
Intendance	—	—	1
Medical	—	1	—
Total	4	12	15

General Svistounou, Chief of the Staff of the District, directed the manœuvre, which was one of a double action, and had on his Staff as Umpires, one General and six Colonels. The work was divided into six periods: (1) Seven days for studying all documents and statistics relating to the theatre of operations. (2) Fifteen days in preparatory work. (3) Five days in examination of the preparatory dispositions. (4) Twelve days in reconnoitring and going over the ground. (5) Three days in studying the fortress of Alexandropol. (6) Twelve days in carrying out the tactical manœuvres contained in the General Idea of the Tour. The whole work occupied fifty-four days, of which twenty-four were spent on the ground itself. The preparatory work consisted of a detailed examination of the necessary measures for putting the Army of the Caucasus on a war footing, accompanied by written reports such as would be drawn up in reality.

Before describing it, it is only necessary to preface, that by the new law of,

January, 1874, only one-fourth to one-fifth of the number of men liable for military service by the conscription, are enrolled as the annual contingent. The remainder pass into the militia and serve for four years in district regiments with the liability of being called upon for the active army. For the next sixteen years, they form part of the district militia force.

The officers engaged in the Tour decided the following problems:

I. Placing the militia of the district on a war-footing according to their new organization; the measures required for augmenting the ranks of the standing army from the district regiments; the mobilisation, equipment, and armament of the reserves with their corps; the time required after the arrival of the reserves to organise each branch of the army serving in the district, separating the men fit to take the field, from those to remain as a garrison; calculation of the number of officers wanting, and the means of completing the cadre; all preliminary measures considered indispensable.

II. Calculation of the time required to bring reserves into the district; steps to accelerate this; organisation of means of transport.

III. The advantages and inconveniences likely to result from concentrating the troops at the points of assembly with such effective as they had at the moment they were ordered to mobilise, without waiting to raise them to their war-strength; measures to be taken by the Staff of the Caucasian Division of Grenadiers, and of the 15th Regiment of Caucasian Dragoons relative to the arrival of the reserves, their equipment, armament, distribution, and transport to their respective regiments and companies; the steps to be taken by the Intendance; the necessary modifications in these dispositions for the other branches of the Army of the Caucasus.

IV. Putting the Army of the Caucasus on a war footing; the railway *matériel* which would be required; calculation of the number of horses and baggage-waggons, of the amount of ammunition and food required for officers and men, with the length of time to complete the effective in draught horses; the minimum time to put the corps *en route* after the arrival of the reserves; all indispensable preliminary measures; the orders and instructions which the Staff of the District would have to send to the Divisional Staffs, and the latter to the Regimental Staffs.

V. The same for each fraction of the artillery—garrison, siege and field artillery; distribution of the artillery parks and supplies according to the concentration of the troops; necessary measures to supply the parks in case the war was of long duration.

VI. Preparations and time required for mobilising the Cossack regiments of the first class;[1] the number of men they would be able to send into the field; measures for replacing the Cossacks in the postal and other departments which they carry on during peace; concentration of the second and third classes; officers and transport for them; orders and instructions which the Staff of the district would have to send to the Cossack military administrators.

VII. Mobilisation and concentration of the Trans-Caucasian troops; repairs to the principal roads; route stations; dispositions for billeting and cantoning troops there during the various seasons of the year; complete details of the steps which the Staff of the District would take to expedite this matter; an accurate route-journal of the Trans-Caucasus district, comprising Western Caucasus and Daghestan.

VIII. Preparations on the railway from Rostow to Vladikav-Kaz in order to mobilise and concentrate the troops of Western Caucasus and Daghestan; calculation of the different columns to move along the military road of Georgia; steps to be taken to avoid impeding movements and ordinary traffic in the opposite direction as much as possible; route-stations and bivouacs for the troops there during the

[1] Since 1874, the Cossacks have been organised into three classes. The first class are trained in their villages till the age of twenty-one, when they pass into the second. In this class they are embodied in regiments for four years, after which they are granted furlough for eight more. The service in the third or reserve class lasts five years.

different seasons of the year; preparations to be made along the route; route-journal of the military road of Georgia, as far as the village of Mtskheta.[1]

IX. Organisation of the route-service in rear of the Trans-Caucasian Army and on the military road of Georgia; repair and maintenance of roads and bridges along the lines of communication, and all preparatory dispositions for forming stations for horses, for the post and for the telegraph.

X. Assuring forage and rations for troops marching on the points of concentration; positions of magazines, and quantity of stores; erection of barns for storing corn and the number of waggons required for such work; Staff of Intendance and means of recruiting it during war; the orders and dispositions for these operations.

XI. Medical and hospital service; resources ready and those necessary to complete; divisional and temporary military hospitals; construction and transport of huts for barracks in the field; distribution of the hospitals in proportion to the troops, and transport of medical stores; route-station hospitals; hospital and medical staff for the army in time of war; means of completing and recruiting it; measures to organise existing permanent hospitals.

XII. The quantity of waggons to complete the trains attached to the Staff, Artillery, Engineer, Intendance and Sanitary services; rolling stock available in the district; subdivision of the trains into classes according to the urgency and importance of their loads; organisation of these classes.

XIII. Organisation of the Staff of the army of operations and of detachments; local military commands, their staffs and means of recruiting them; preparation of the maps to be furnished to the Staff; indispensable stores to be provided for them.

XIV. Means of raising the Brigade of Engineers in the Caucasus to a war footing; engineering tools, stores and materials.

The preparatory work was examined when completed in the presence of the whole detachment of officers, who were assembled for the purpose. Those who prepared the reports supported their conclusions against any criticism offered. After being corrected in this way, they were submitted to the director of the Tour for approval. The reconnaissance of the ground and of the fortress of Alexandropol was then commenced, and the map of the district, on a scale of a foot to five thousand yards, was corrected. Printed instructions indicating the daily distribution of work, the time to be taken over each study, the points to be verified on the spot, and forms of marching reports, memoranda and orders were issued to each officer before beginning the operations in the field. The General Idea was one of a double action, but until the forces approached within two marches of one another the manœuvres were carried out on the maps made during the reconnaissances as in Kriegs-spiel.[2] The two parties and the Umpires went into separate cantonments and communicated with one another by Cossacks. All messages had to be made in writing, and to be transmitted through the Umpires, who made known their decisions in the same way. The Staff drew up the dispositions and orders for the different arms, and the regimental officers determined sites for bivouacs. When a column was ordered to move by any road, an officer with a party of Cossacks carrying flags to indicate the troops composing it, were sent to represent it. He observed strictly the speed which the column would really move at, and showed by a dot on the map he made as he went, his position every quarter of an hour. Map-tables were thence compiled for the movements of all the columns every day they marched. The advantage of this method for facilitating the direction of the manœuvres and giving them clearness and precision is declared to have outweighed any disadvantage of tediousness. After the work in the field was finished, the officers assembled and their operations were reviewed and criticised.

Such a Tour as this, which included a complete mobilisation and concentration of the Russian army on the Trans-Caucasian frontier, cannot but lead to the inference that operations against Turkey were even then in course of preparation. In itself the record of the Tour is interesting, as showing the numerous points of military administration which should be worked out by the Staff in time of peace. But it

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[1] Twenty miles north of Tiflis.

[2] What the General Idea was does not appear to have been published in the accounts of the Tour at hand.—L. A. H.

has a special interest as giving us an insight into what Russia thought of a war in Asia against Turkey in 1874. The mention of measures to be taken "in case the "war is of long duration," of making preparations for the troops being cantoned "at "all seasons of the year," and the concentration of "the third class of Cossacks," all point to a conviction on their part that such war would not be finished by one year's campaigning. We all know now that this was a correct view of the case. We have seen Russia's Asiatic army make a rush of conquest almost to the gates of Erzeroum, and we have seen it slowly beaten back, only to renew the contest. There is not a doubt that much of the success at the outset was due to the state of preparation military affairs were in. There is equally little reason for doubting that they were beaten back owing to the inefficiency of those who directed the operations. They neglected to observe the commonest military maxims, and they have suffered for their neglect. But the Tour undertaken in the autumn of 1874 in the Caucasus district, and Tours such as this, collected the information and arranged the preliminary dispositions on which the forces were mobilised, concentrated, and organised along the frontiers in Europe and Asia. They formed almost the only training in Staff-duties that officers in Russia went through.

The Staff Academy in St. Petersburg has always wanted candidates, and a large proportion of the General Staff are appointed direct from regiments without going through any special training. Tours of themselves will not suffice to instruct an officer possessed of only a limited knowledge of military exercises, in the many and various branches a Staff Officer must be acquainted with. But they form a valuable supplement to other training, and Russia has already found reason to appreciate their value. Throughout the war with Turkey, the ignorance and inefficiency of the Staff has been proclaimed and openly discussed in the papers. At this moment the cries of the men have found public expression. "Send away the fools! "give us good generals and we will fight well enough." But at the same time let it be remembered that there is very little education amongst the men, and that they were illiterate serfs but a few years ago. Intelligence will make a wooden automaton do what it wishes, but put a small spark of knowledge into it and call it a man, and it becomes a very difficult thing to deal with. All history shows that if reverses occur in war, the Staff have to bear the onus of them. The Austrian Staff were saddled with the disasters of 1866, and the corps had to submit to reorganisation in consequence. The French Armies, with equal truth, were "betrayed" by their Generals in the struggle with Germany. No nation, therefore, can afford to neglect any means by which the intelligence of the Staff of the Army can be improved; and Staff Tours form one of these means. From the earlier Russian Tours we see that the simplest questions of Staff administration can be solved in them without causing any feeling of time being wasted, or of the object being insignificant. On the contrary, points arose which called for a prompt solution, such as only those who had much military experience could at first give. When the Medical and Intendance Departments were associated in them they still maintained a practical form. By degrees they advanced beyond being a mere training school, they became a permanent part of the military organisation of the country, and the work done in them formed the basis of the present war with Turkey.

Such then is the system of training applied to Staff Officers abroad; and it would seem to be well suited to its purpose.

Few will agree with Lord Macaulay, that perhaps plain good sense, a quick eye, a cool head, and a stout heart are the only requirements in military art. It might have been so in the times of the civil wars in the seventeenth century. It certainly is not so now. Practice is the requirement that runs through every line of life to make it profitable.

NOTE.—Several publications have been received, and are awaiting notice, which for want of space is unavoidably deferred.—L. A. H.